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(English Edition)

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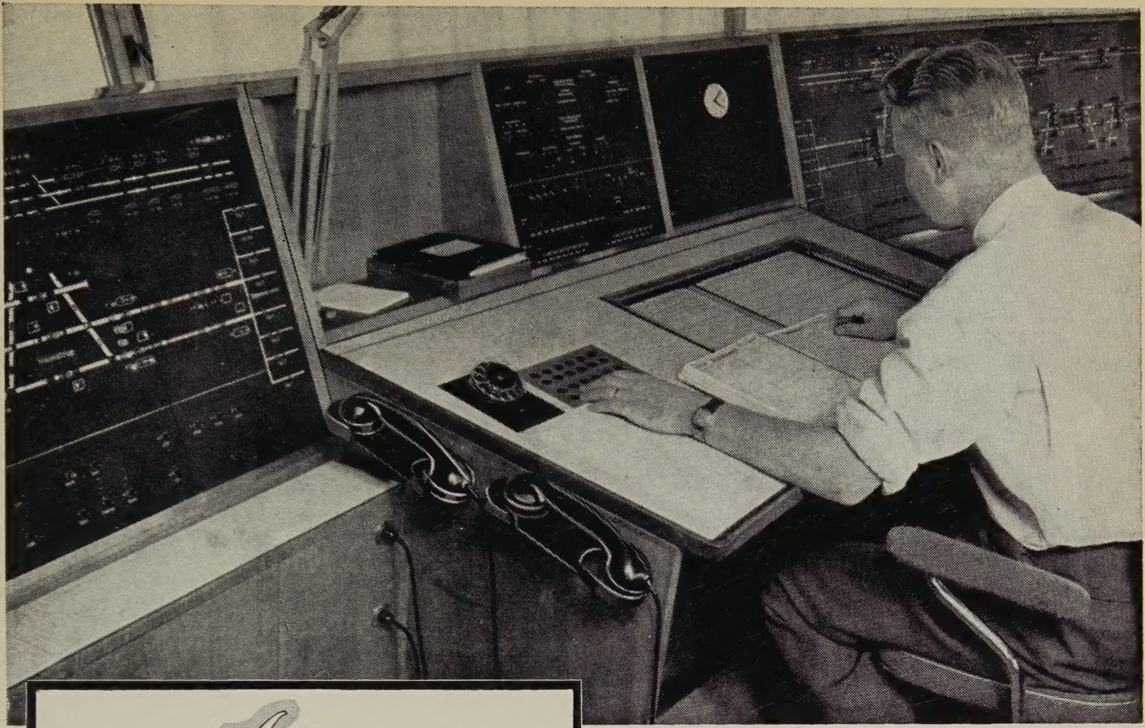

C.T.C. office at Odense for Nyborg — Fredericia line

Danish State Railways install C.T.C.

The Danish State Railways opened their first C.T.C. installation in 1956. That was between Vordingborg and Masnedø across the bridge linking the islands of Zealand and Falster. A second C.T.C. plant, on the line between Tommerup and Nyborg in the island of Fyn, was commissioned in 1957, and a third — between Nykøbing and Gedser — in 1959.

In the next few years the Danish Railways intend to install C.T.C. on several other lines and, in relation to total railway mileage, will then be one of the biggest users of C.T.C. in Europe.

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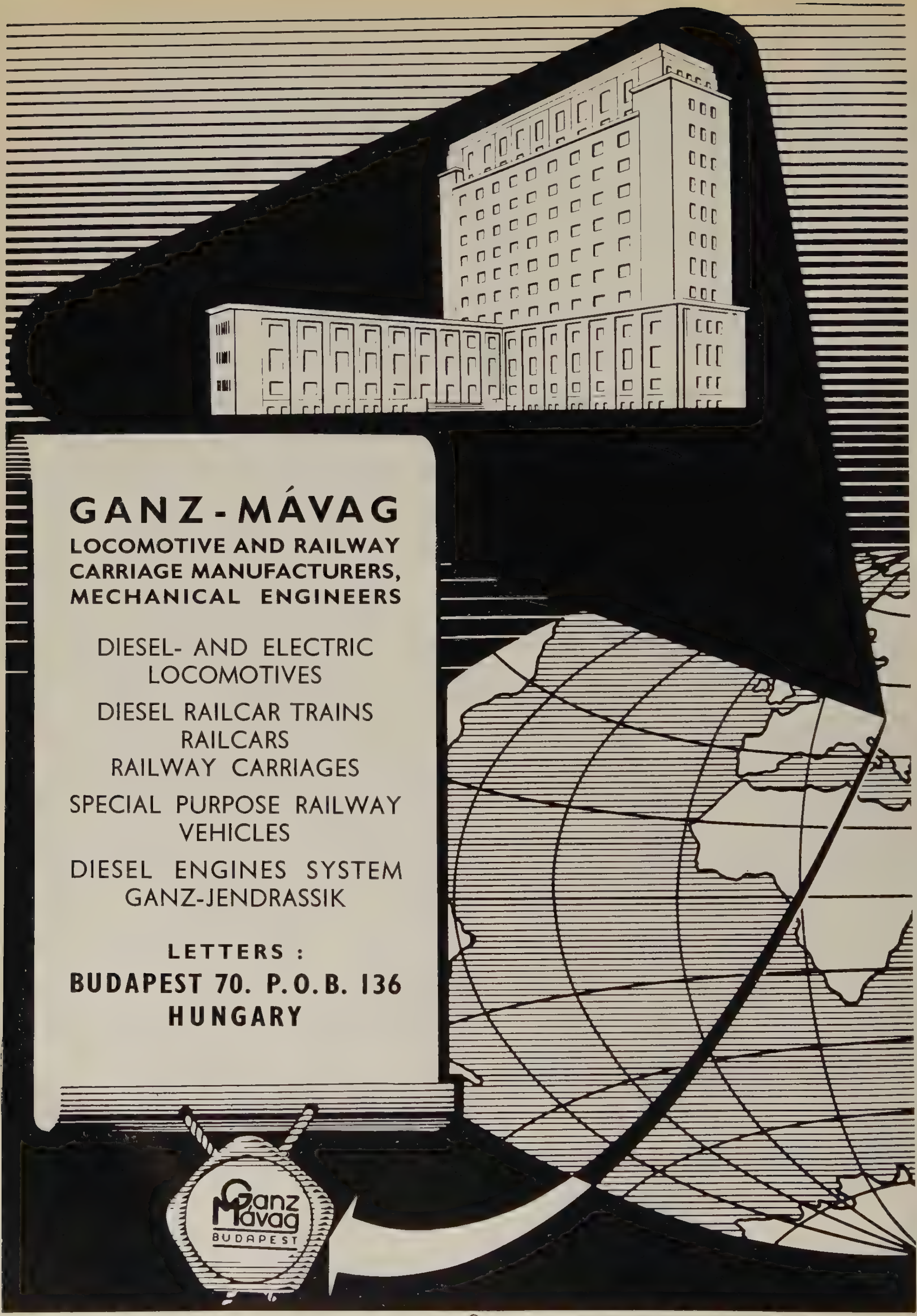
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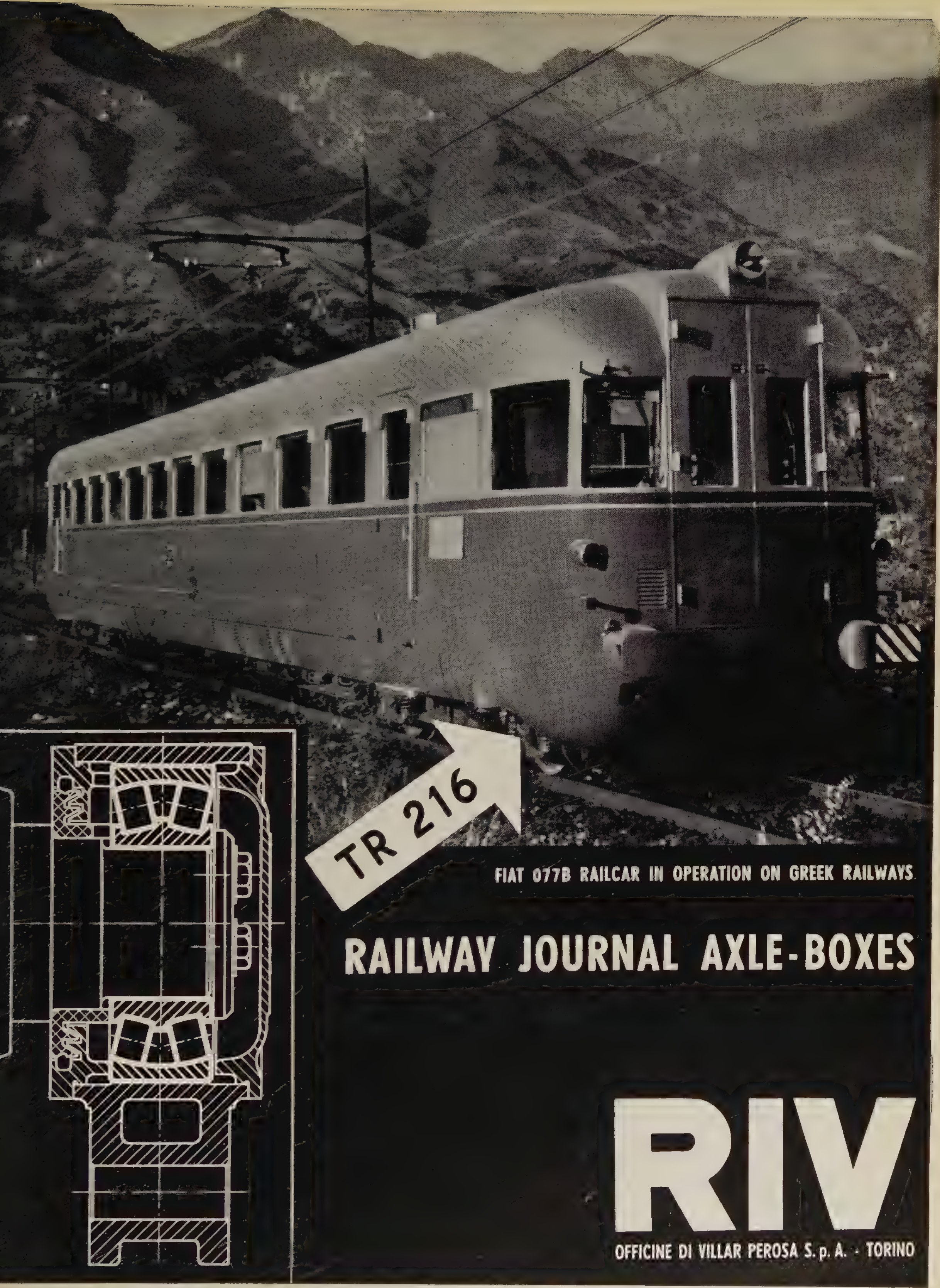
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OF THE

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .25]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

ENLARGED MEETING OF THE PERMANENT COMMISSION
(BRUSSELS, 1960).

QUESTION 1.

The effect of electric traction on signalling and communication circuits, in particular reference to the means of overcoming interference, to provide safety and good communications.

REPORT

(America (North and South), Australia, Burma, Ceylon, Egypt, Ghana, India, Irak, Iran, Republic of Ireland, Japan, Malaysia, Netherlands, New Zealand, Norway, Pakistan, Phillipines, South Africa, Sudan, Sweden, Union of Socialist Soviet Republics, United Kingdom of Great Britain & Northern Ireland and dependent overseas territories and Uruguay),

by Sven SVENSSON,
Elektrotekniska Byrån, Kungl. Järnvägsstyrelsen, Sweden.

and J.A. BROUGHALL,
Electrical Engineer (Development), British Transport Commission, British Railways Division.

PRELIMINARY REMARKS.

In order to obtain sufficient data for the report on Question 1, a detailed questionnaire was sent to 34 Administrations. Sixteen of these were not able to make comments; six have not answered at all.

Only the following Administrations Egypt (*), India, Japan, Netherlands, New Zealand, Norway, South Africa, Sweden, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland and Victoria have supplied detailed replies — New Zealand's reply is restricted to Chapters II and III. The Association of American Railroads supplied a report on inductive co-ordination, dated 15th July, 1936, concerned with electrical supply systems and the telecommunication systems of railways which could not therefore be used in connection with the questionnaire.

(*) The reply to the Questionnaire received from the Egyptian Railways reached us too late to be included in this report, but upon examination the information they give confirms but does not modify the conclusions of the report and tables.

CONTENTS.

INTRODUCTION.

The effect of electric traction on signalling and telecommunication circuits and the means to be adopted for overcoming interference so as to ensure safety and good communications depend naturally on the system of electric traction used on the one hand and on the system of signalling and telecommunication on the other.

As will be seen from the detailed replies summarised later in this report, the practice of the Administrations with which it is concerned differs greatly in both respects. The replies include information about electrification on the direct current system at three different voltages and on the alternating current system at four voltages and four frequencies (see Table 1). On the signalling side they include more than ten methods of track circuiting (see Tables 10*a* and 10*b*) and some twenty systems of telecommunications (see Table 12) although the distinction between these is not always so clearly defined as in the case of electric traction systems. As the report deals only with replies from ten Administrations, it is clearly difficult to summarise them in a general way as the amount of evidence is inadequate having regard to the number of major variables concerned.

The extent of the interfering effects and the best methods for minimising these

TABLE 1. — T

Railway Administration; Question	*British Railways (end of 1958)*			*Indian State Railways*		
1.3 Traction system	D. C. 660 V	D. C. 1 500 V	A. C. 50 c/s 25/6.25 kV	D. C. 1 500 V	D. C. 3 000 V	A 5 2. (pl
1.31 Route length in kilometres of single track lines	—	—	—	6	35	1
1.32 Route length in kilometres of double or multiple track lines	1 395	212	15	436	106	1
1.33 Total single track length in kilometres excluding sidings etc.	3 260	595	29	939	306	2

is also, however, dependent upon a number of other variables such as the type of motive power units, the relative disposition of the power distribution lines and signalling and telecommunication circuits to one another and the physical form of the cables and networks comprising these latter circuits. The number of variants in these elements defies numerical classification.

Wherever any electric power line is in the vicinity of a signalling or telecommunication system, there is, for fundamental reasons, a tendency to transfer energy from the high power circuit to the low power circuit. The transfer occurs in two ways, one depending primarily upon the amount of current in the high power circuit and the other on its voltage. The extent of the transfer depends upon the relative physical disposition of the two circuits and the screening of the low power circuit. The presence of harmonics in the high power circuit in addition to the fundamental must also be taken into account. It is clear, therefore, that the number of factors involved in elucidating the problem is very large. Figure 1 illustrates the factors named above in diagrammatic form. This diagram also indicates other additional factors of importance and was the basis upon which the questionnaire to which the replies summarised in this report was formed.

It is thought that this brief analysis of the essentials of the problem will be of assistance to those studying the report and that, coupled with the diagram, it will assist in a clear understanding of how interference arises and how it is avoided or cured.

The foregoing would be a fair statement of the problem if each Administration had adopted a single system of electric traction and of signalling and telecom-

	Japanese National Railways	*Netherlands Railways*	*Norwegian State Railways*	*South African Railways*	*Swedish State Railways*		*U.S.S.R.*			*Victorian Government Railways*
V	A. C. 50+60 c/s 20 kV	D. C. 1 500 V	A. C. 16 2/3 c/s 15 kV	D. C. 3 000 V	D. C. 1 500 V	A. C. 16 2/3 c/s 15 kV	D. C. 1 500 V	D. C. 3 000 V	A. C. 50 c/s 25 kV	D. C. 1 500 V
	77	160	1 463	1 546	95	6 213 including two privately owned railways	384	8 968	137	122
	18	1 460	68		12	1 023				296
2	142	3 100	1 599	3 520	119	8 259 including two privately owned railways	no figures given			810

Effects of electric traction on signalling and telecommunication circuits.

POWER SIDE				
Power supply	*Types of substations*	*Traction systems*	*Relevant particulars of the traction system*	*Compensating factors*
Public supply / Railway owned generation and network			*1.411/1.44/1.444* Design of traction supply distribution circuits	*1.51* Track
				1.511/1.512/1.515 Rails
1.121 Feed of substations	*1.22* Transformer			*1.513* Bonds
1.122 Voltage of high tension lines	*1.22* Motor-generator		*1.42* Frequency	*1.514* Contact line masts
	1.231 Rotary-converter		*1.43* Voltage	*1.516/1.517/1.518* Circuit rail-earth
1.123 Only railway supplied ?	*1.231* Rectifier	*1.3* A.C.	*1.45/1.46* Load current	*1.521* Booster transformers
1.124 Alignment of high tension lines	*1.232* Use of filters	*1.3* D.C.	*1.452/1.453* Harmonics	*1.531* Return conductors
1.125 Neutral points of high tension lines	*1.24* Input harmonics		*1.471* Short-circuit current	*1.519/1.532* Loop impedance
1.126 Selective protection automatic reclosure	*1.25* Short-circuit level		*1.472/1.473* Sudden variations of current	*1.541* Compensating wires
1.127 Transpositions of high tension lines	*1.26* Fault protection		*1.48* Resistivity of earth	*1.542/1.543* Other devices for reducing the interference
				1.55 Experiences

Fig. 1.

Effects of electric traction on signalling and telecommunication circuits *(continued).*

COUPLING			
Resulting interfering effects	*Arrangement of signalling and telecommunication circuits and their protection*	*Cables*	*Special protection devices*
2.11/2.12/2.13 Currents in screening conductors	*2.211* Position to track	*2.221/2.222/2.223* Arrangement of cables	*2.231.1/2.231.2* Sectionalisation of circuits
2.14/2.15 Electrostatic screening	*2.212.1* Position to ground	*2.224.1/2.224.2* Cable structure	*2.231.3/2.231.4* Maximum induced voltage envisaged
	2.212.2 Transverse dimensions	*2.224.3/2.224.4* Test voltage	*2.233.1/2.233.2* Control of conductor insulation
	2.212.3 Distance between conductors	*2.224.5* Sheath partitioned ?	*2.234.1/2.234.2/2.234.4* Excess current protection devices
	2.212.4/2.212.5 Transpositions	*2.224.6* Sheath earthed ?	*2.234.3* Lightning arresters
	2.212.6 Special devices	*2.224.7* Screening factors	*2.234.5* Devices against acoustic shocks
	2.213.1/2.213.2/2.213.3 Sensitivity coefficient		*2.235* Other special arrangements

Fig. 1 *(continued).*

Effects of electric traction on signalling and telecommunication circuits *(continued)*.

SIGNALLING AND TELECOMMUNICATION SIDE				
Effects	*Services affected by corrosion*	*Systems of signalling*	*Other types of signalling circuits*	*Systems of telecommunications*
		3.311.1/3.312.1 Length of single rail track circuits		
		3.311.2/3.312.1/ 3.311.3 Type of feed for track circuits		
		3.311.41/3.312.31/ 3.312.32/3.312.33/ 3.312.51 Frequency of track circuits		
		3.311.42/3.311.43/ 3.312.4 /3.312.52/ 3.312.53 Precautions against disturbances	*3.321* Other types of signalling circuits	*3.331.1* Telecommunication circuits used for telephony
3.111 Disturbance by fundamental frequency or by harmonics	*3.21* Difficulties due to corrosions on railway signalling	*3.311.44/3.312.8* Relays	*3.322* Metallic connections to earth	*3.331.2* Telecommunication circuits used for telegraphy
3.112 Danger to persons or equipment	*3.22* Difficulties due to corrosion on railway telecommunications	*3.311.45* Types of circuits	*3.323* Sensitivity coefficient	
		3.311.46 Protection against saturation effects in single-rail track circuits	*3.324* Limiting values	*3.332* Metallic connections to earth
3.12 Precautions when working on telecommunication circuits	*3.23* Difficulties due to corrosion on public telecommunications	*3.311.47/3.312.6/ 3.312.7* Special precautions with regard to impedance bonds	*3.325* Effects of the traction current on these signalling circuits	*3.333* Sensitivity coefficient *3.334* Limiting values
		3.311.48/3.311.49/ 3.312.2 Protective devices for circuits		
		3.312.9/3.312.93 Effects of the traction current on track circuits		
		3.313 Track circuits in stations with several electrification systems		

Fig. 1 *(continued)*,

munication throughout its history. This, however, is by no means the case. More than one Administration has differing systems of electric traction in use and systems of signalling and telecommunication engineering have also varied from time to time with development of the art. It was necessary therefore to ask the Administrations to give particulars in respect of a limited number of the systems that they have actually in use today. It was suggested that each Administration should give the fullest possible particulars concerning the interaction between the principal system of traction at present in use and the principal system of signalling and telecommunication, and this report concerns mainly replies framed on these lines. In addition, however, the Administrations were asked to give coresponding particulars of any other systems which have been or are in use, and which are considered to be significant as providing information about other solutions if they throw light on the problem under discussion. Further, each Administration was asked to provide any additional information which they considered significant for the solution of the problem.

Where the replies were numerous and could conveniently be summarised, they have been given in a series of tables forming part of this report. Where only a few replies were received to a question or where a brief summary would be misleading, the replies are dealt with in the body of this report. The report deals generally with the answers in the order in which the questions occur and therefore corresponds generally to the order of figure 1, with two main exceptions. Particulars regarding soil resistivity — Question 1.48 will be found at the beginning of Chapter II, and particulars of the effects observed will be found at the end and not at the beginning of Chapter III.

Finally, it should be noted that, complicated though the problem is and although many different solutions have been found, in every case the measures are sufficient to avoid any questions of danger to personnel or to apparatus and to ensure the proper functioning of the equipment and so permit satisfactory operation of all the railways concerned.

* * *

CHAPTER I.

1.1. Power supply.

The questions about power supply were included because there is a possibility of interference with communication circuits, particularly from high tension open wire lines supplying a railway and also certain measures which might be taken to reduce interference could react on the power supply system. In fact, it does not appear from the answers that this is the case for the railways under consideration and the replies have not been tabulated in detail. Most of the railways obtain their power from the public three-phase network. This method is used for nearly all D.C. railways and of course for A.C. railways operating at standard frequency. The possibility of using this form of supply is a very important advantage of A.C. traction at standard frequency. The public supply is also used for the two railways using low frequency A.C. (Sweden and Norway), who derive their low frequency supply from motor generator sets.

On D.C. railways it is usual for power to be taken at relatively few points and distributed to substations by railway-owned cables, although occasionally open wire lines are used to connect the supply point to the various substations. When cables are used, the voltage is normally between 20 and 33 kV and in such cases the cables have practically no influence on the interference problem. In one case, in India, open wire lines at 95 kV are used. but although this line closely follows the railway and therefore the signalling and telecommunication networks, it does not appear to create any difficulty with them. An exception to this is the reply of the Victorian Government Railways, mentioned in Table 13, who have ex-

perienced disturbances from their power distribution lines associated both with fundamental and audio frequency harmonics. The reply does not give sufficient detail to warrant further comment.

On A.C. railways low frequency single phase high voltage lines may be owned by the railway and may often, but not always, follow the track. Parallelisms occur more frequently in this case, but it would not appear that difficulties have arisen from this cause.

A series of questions designed to ascertain whether this immunity persists under abnormal voltage and under fault conditions, included questions relating to the method of removing faults from the system. A great diversity of transmission voltages, from 5 kV to 220 kV, is used and the permissible voltage limits vary from ± 3 % to ± 12 ½ %. The clearance of faults normally depends upon over-current protection operating simultaneously on all three phases. Faults are normally cleared in less than 0.5 sec, the minimum time being 0.1 sec (India) and the maximum 7 sec (U.S.S.R.). Automatic reclosure is employed only in Japan and U.S.S.R., but it is planned for use in India on 50 cycles A.C. traction. In most cases the neutral points are solidly earthed at some point but not necessarily at all transformers. In a number of cases arc suppression coils are used, and sometimes the earth connection is made through a resistance. Occasionally the neutral point is unearthed. In most cases where overhead lines are involved transpositions are made.

The replies to these questions show that where railways are supplied from the public network, they take less than 10 % of the power available at the point of supply, considering a railway system as a whole. At individual supply points, the proportion is sometimes much higher. Where the Railway owns the distribution lines from the power station to the substations, the load is usually entirely a traction one, but in some cases, e.g. Netherlands, other consumers are connected to cable feeders used mainly by the railway.

In short, it would not appear that the type and arrangement of the generating stations or of the high voltage transmission lines has any other effect upon the interference problem for the Administrations concerned than any other A.C. power supply system.

1.2. Types of substations.

The main replies to the series of questions dealing with the types of substations are summarised in Table 2 *a*) for railways electrified on the D.C. system and in Table 2 *b*) for railways electrified on the A.C. system.

For D.C. railways, all Administrations use 6 or 12-phase mercury arc rectifiers, but some motor generator and rotary converter sets remain in use on the South African and Victorian Railways. Five of these seven railways fit filters to reduce the harmonic content of the rectified current but neither the British nor Netherlands Railways do so although the Netherlands Railways use 6-phase rectifiers. Table 2 *a*) gives particulars of the harmonic contents on the D.C. side where this has been given. The feeders from the substation to the track are nearly always protected by high speed circuit breakers which operate to disconnect a fault in times which normally vary from 0.007 to 0.02 sec although this time is shown in Table 2 to be sometimes as high as 0.15 sec. Five railways use automatic reclosure. The number of reclosures varies from one to four and in the case of the Netherlands Railways an earth test is made before reclosure.

For A.C. traction, except in the case of Norway and Sweden, the substations contain single phase transformers and occasionally Scott-connection or other methods are used to assist in balancing the load over the three phases of the public network. In the case of Norway and Sweden, a balanced load is obtained

Railway Administration : *Question*	*British Railways*	*Indian State Railways*	*Japanese National Railways*	*Netherlands Railways*	*South African Railways*	*U.S.S.R.*	*Victorian Government Railways*
1.231 Description	12-phase mercury arc rectifiers without grid control.	6-phase and 12-phase mercury arc rectifiers, some with grid protection.	1/3 of power rotary converters. 2/3 6-phase rectifiers, normally without grid control.	6-phase mercury arc rectifiers with grid protection.	6-phase and 12-phase mercury arc rectifiers with grid control. Some motor-generator.	6-phase mercury arc rectifiers with grid protection. Grid control for convertors only.	Mostly 12-phase, some 6-phase mercury arc rectifiers, some rotary convertors.
1.232 Are filters used?	No	Generally 4 filters with 6-phase rectifiers. 1 or 2 with 12-phase.	Yes	No	Yes	Yes, reactors and 4 resonant shunts.	Yes, reducing harmonics to B.S.S. standards.
1.24 Magnitude of principal harmonics at input	Not known yet	Not known	$3/n^2$ of fundamental, thus: 5th: 12 % 7th: 6.1 % 11th: 2.5 % 13th: 1.8 %	Not known	Not known	Maximum : 5th: 20 % 7th: 5.5 % 11th: 1.5 % 13th: 2.5 %	Not known
1.26 Protection of outgoing feeder	High - speed breakers, tripped by rate of rise of current.	High - speed breakers, overcurrent and short - circuit tripped.	High - speed breakers, discerning between overload and fault.	High - speed breakers.	High - speed breakers, tripped by rate of rise of current.	High - speed breakers.	High - speed breakers.
1.261 Time of disconnection in seconds . . .	0.007	0.007 to 0.016	0.02 to 0.04	0.01 to 0.02	0.02 to 0.08	0.03 to 0.07	0.05 to 0.15
1.262 Automatic reclosure after ..... seconds . .	Generally not used. 1 or 2 reclosures in stations of 1 line.	Used in part of stations, 3 to 4 times after 15, 30, 45 or 16, 28, 40, 52.	Not used	With earth test after 10, 60, 110.	In some substations, after 15 ...... 105.	Twice 10, 25.	Not used.

TABLE 2 *b.* — **A. C. Substations.**

Railway Administration : *Question*	*British Railways*	*Indian State Railways*	*Japanese National Railways*	*Norwegian State Railways*	*Swedish State Railways*	*U.S.S.R.*
1.22 *Description* . .	Transformers fed from 3-phase public network. Balancing of load over consecutive substations, in a few cases by Scott transformers.	Transformers fed from 3-phase public network. Balancing of load over consecutive substations.	Transformers fed from 3-phase public network. Scott transformers will be used.	Mainly motor generators fed from 3-phase public network. Load is balanced.	Motor - generators fed from 3-phase public network. Load is balanced.	Transformers fed from 3-phase public network. Balancing of load over consecutive substations and by feeding both directions of each substation from two sides of a Δ-winding.
1.24 *Magnitude of principal harmonics at input* . .	Not known yet.	Not known.	Not known.	Not known.	Not known. 3-phase and single-phase sides are independent.	Not known.
1.25 *Short-circuit level at the input of substations in MVA*	2 500 at 25 kV 350 at 6.25 kV	— 600 to 1 400	90 to 240 average 170	— —	— —	— 80 to 200
1.26 *Protection of outgoing feeders* . .	Distance / impedance protection.	Overcurrent / admittance protection contemplated	Overcurrent and high speed impedance protection.	Overcurrent and rate of rise of current protection.	Overcurrent, rate of rise of current and distance protection.	—
1.261 *Time of disconnection in seconds*	0.5 to 1 depends on current intensity.	0.1	0.11 to 0.17	0.06 to 0.25	0.06 to 0.14	—
1.262 *Automatic reclosure after ...... seconds*	Once after 10.	Not used.	Once after 0.5. No earth test.	Partly used, with or without earth test. After 5, 35, 215.	Automatic test after 5,35, 215.	—

by the use of motor generators to supply the low frequency current. The replies do not give any information about the harmonic currents associated with these supplies and show, as was expected, a wide difference in the fault level at the input to the substations. The outgoing feeders to the overhead contact line are equipped with circuit breakers and usually with high speed impedance protection giving disconnection times varying from 0.06 to 0.25 sec. Automatic reclosure is used in four of the five railways for which complete particulars are given; in two cases, one reclosure is allowed. In the case of Norway and Sweden, three reclosures are made.

It must be admitted that the replies do not produce a clear picture of the fault level and the distance over which fault curents may flow in a railway electrified on overhead contact system. They do imply that big differences exist from one railway to another and that any generalised formula for associating interference effects with short circuit currents is not at present possible, particularly in view of the wide differences shown in the replies received to the various parts of questions 1.3 and 1.4.

1.3. Traction systems.

1.4. Relevant particulars of the traction system.

With the exception of a part of the British Railways' reply, all the replies deal with overhead systems and are summarised in Table 3 *a*) as regards D.C. systems and 3 *b*) as regards A.C. systems.

For D.C. traction, substations are normally connected in parallel, but both the normal and the emergency distance between substations varies over wide limits depending on the voltage of the electrification and the class of service.

For A.C. traction, substations are normally connected in parallel in Sweden and U.S.S.R. but not in the other three countries for which particulars are given. A sectioning post midway between substations is normal. The mean separation again depends upon the voltage and frequency and no doubt on the type of service. Apart from the special British case where 6.25 kV is used in a small part of the system, the mean normal distance between substations varies from 40 to 100 km in comparison with 5 to 20 for D.C. railways.

Table 3 *b*) gives some particulars of the normal load current and of fault current on A.C. traction systems, the former varying from 200 to 650 amps and the latter from 600 to 3 000 amps.

Table 4 gives particulars of the motive power units in terms of their continuous rating which again vary widely according to the traffic demands of the railway. It is clear that there is not yet agreement on the permissible degree of undulation of current supplied to the motors of rectifier type motive power units or knowledge of the harmonic content on the A.C. side. Some particulars of the latter are given by the Japanese Railways (see Table 4) and the U.S.S.R. gives the following table showing the magnitude of the harmonic current in relation to the total current, but the extent to which this is generally applicable in the U.S.S.R. is not clear :

1	3	5	7	9	11	13	15
93.2	14.0	4.8	2.4	1.44	1.0	0.72	0.56
17	19	21	23	25	27	29	31
0.40	0.32	0.24	0.17	0.14	0.11	0.076	0.056

The Swedish State Railways give a measured maximum value of the equivalent disturbing current of 1 amp for locomotives with A.C. commutator motors.

The replies given in Table 4 do not therefore form a very satisfactory basis either for assessing the magnitude of the harmonic currents flowing in the overhead traction system or of those flowing in the supply, both of which are potentially of importance in evaluating the interference problem, especially as regards

Railway Administration : Question		British Railways	Indian State Railways	Japanese Nationa Railways
1.431	*Nominal voltages in kilovolts and variations* — *at the output of substation*	0.66, + 19 % — 25 %	1.50 + 5 to 7 % — 3 to 13 % 3.00 + 7 %	1.50, + 10 % — 3
1.432	*Nominal voltages in kilovolts and variations* — *at the motive power unit, average*	0.60	1.40 2.90	1.35
1.433	*Nominal voltages in kilovolts and variations* — *at the motive power unit, minimum*	0.40	1.00 to 1.15 2.60 (emergency 2.00)	1.00
1.472	*Values used for the calculation of the effects of short-circuit* — *Initial rate of rise of current*	at busbar : 1.65×10^6 amps/sec at 3 km distance 135 000 amps/sec at 5 km distance 85 000 amps/sec	—	at 15 km distance : 67 000 amps/sec single track 100 000 amps/sec double track
1.473	*Values used for the calculation of the effects of short-circuit* — *Rate of fall of* current	approx. 200 000 amps/sec	—	—
1.412	*Cross section in square millimetres of* — *Contact wire*	Conductor rail, new 6 800 or 9 600 35 to 40 % less when fully worn	130 to 195	—
1.412	*Cross section in square millimetres of* — *Catenary*		200 to 240	—
1.412	*Distance between contact wire and track centre in metres* .	1.13 (rail)	5.3	5.2
1.44	*Method of supply and sectionalizing*	The substations are connected in parallel. The conductor rails for different tracks are connected to a common bus-bar, by means of breakers, at substations and intermediate switching points, approx. every 3 km.	Arrangements vary for different lines. Generally supply from both ends; contact wires are paralleled. Sectionalizing posts are provided, when required. In a four track section, two tracks will be de-energised in the case of a fault.	*Single track:* Substa are connected by a fe wire, with isolator stations. Contact wi sectionalized at each of each station; these tions are fed by taps feeder wire at interva 240 to 500 m. *Double track:* Sin but a sectioning post circuit breakers is pro ed half-way between stations; here, both der wires are parall

1.444 *Distance between substations in kilometres*		British Railways	Indian 1.5 kV	Indian 3.0 kV	Japanese suburban	Japanese trun
normal	*mean*	5.6	7 to 20	18	5.1	13.
normal	*max.*	7.2	21 to 25	21	11.2	21.
emergency	*mean*	—	—	36	9.7	26.
emergency	*max.*	14.4	27 to 45	42	20.4	42.

Netherlands Railways	South African Railways	U.S.S.R.	Victorian Government Railways	
1.50, + 20 %	3.00	—	1.50, + 5 % — 10 %	
1.35	2.60 to 3.60 abnormally 2.00 to 4.00	—	1.45	
1.20	2.60 to 3.60 abnormally 2.00 to 4.00	—	1.10	
—	—	—	—	
—	—	—	—	
—	160	—	—	
—	80 to 240	—	—	
5.5	—	6.5	5.3	
ıbstations are connected rallel. The two contact of a double track line onnected to a common r, by means of breakers, h substation and at two ıediate switching points ection, approx. every	—	No information given for D.C. railways.	Normally overhead feeders are used to connect substations with overhead contact wire/catenary system. Feeder circuit breakers are installed at each end of sections; all breakers are normally closed. Each half of substation bus-bar feeds both directions of one track.	
18.8	minimum 4.4	—	suburban 6.3	country 8.7
24	33	—	12	10.5
37.6	—	—	—	—
48	—	—	17	20

Railway Administration : Question			British Railways		Indian State Railways	
1.42	*Frequency, c./s.*		50		50 ± 3 %	
1.431	*Nominal voltages in kilovolts and variations*	*at the output of substation*	25, + 10 % — 30 % 6.25, + 10 % — 30 %		25, + 10% — 5%	
1.432		*at the motive power unit, average*	Not yet sufficiently known		22.5	expect value
1.433		*at the motive power unit, minimum*	Not yet sufficiently known		17.5	
1.46	*Current used for interference calculations, in amps*	*Load current normal*	Evaluated from time tables		600	
1.46		*Load current abnormal*	Evaluated from time tables		—	
1.471		*Short circuit current*	Evaluated from impedance of source, transformer and line		3 000	
1.412	*Cross section in square millimetres of*	*Contact wire*	100 at 25 kV 170 at 6.25 kV		107	
		Catenary	40 at 25 kV 240 at 6.25 kV		65	
1.412	*Distance between contact wire and track centre in metres*		4.80		average 5.5	
1.44	*Methods of supply and sectionalizing*		With some exceptions for 6.25 kV, the substations are not parallel connected, and the contact wires broken about half-way. Contact wires of different tracks are paralleled, by means of breakers, at substations and intermediate switching points, every 12 km at 25 kV, every 6 km at 6.25 kV.		The substations are not pa connected, the contact-wires ken half-way. Contact wire different tracks are parall by means of breakers (no automatic) at substations, i mediate switching points and way sectioning points, thus e 16 to 20 km.	
			25 kV	6.25 kV		
1.444	*Distance between substations in kilometres*	*normal* — *mean*	40	10.5	64	
		normal — *max.*	48	12	80	
		emergency — *mean*	—	—	—	
		emergency — *max.*	96	24	—	

Japanese National Railway	*Norwegian State Railways*	*Swedish State Railways*	*U.S.S.R.*
50 and 60	16 2/3 (15.4 for Narvik-Riksgränsen)	16 2/3 ± 0.1 minimum 15 2/3	50, minimum 49.5
+ 18 % + 10 %	16.2 to 16.5	15 to 16.5	27.5 ± 5 %
20	15	15 to 16.5	25
16	12	12	19
400	200 to 300	500 to 650	—
—	—	—	—
1 500	600	1 200, over 30 to 40 km	—
85 to 170	100	80 or 100	—
55, steel	50	50	—
5.2	5.5	5.6	6.5
tions are not parallel ted; the contact wire is half-way at a section- st and again at 1/4 and subsectioning posts. All osts are equipped with capacitors. In stations, rs are provided. With -track, the contact wires aralleled in the sub- ing posts.	—	Neutral sections provided at the substations and at switching points half-way allow sectionalizing and independent operation. Normally, each contact wire is connected through longitudinally, but parallel connections between the contact wires of a double track section are provided in substations only.	Consecutive substations are parallel connected via contact wire, with a sectionalizing point half-way. On double track railways, both contact wires are connected at substations and sectionalizing point, in the average thus every 25 km.
45	85	100	~ 50
—	210	160	~ 75
45	—	200	~ 100
—	—	240	~ 150

TABLE 4. — Partic

Railway Administration : *Question*	*British Railways*				*Indian State Railways*				
D.C. or A.C. Traction . . . . *Voltages in kilovolts*	D.C. 0.66	D.C. 0.66	A.C. 25	A.C. 25	D.C. 1.5	D.C. 1.5	D.C. 3.0	D.C. 3.0	A.C. 25
Type { *MU = Multiple Unit* . . . . . . *L = Locomotive*	MU	L	MU	L	MU	L	MU	L	MU
1.45 Continuous rating in amps. For MU, rating per unit and maximum number of units coupled	980 × 3	appr. 1 800 and 3 000	40 × 3	150	105 to 145 × 4	530 to 1 700	420 × 2 or 440 × 2	560	—
1.451 Type of motors and rectifiers, if any (A.C.)	—	—	D.C. motors Mercury arc Germanium Silicon Rectifiers provided		—	—	—	—	—
1.452 Arrangement of reactors and filters (A.C. only)	—	—	Reactor on D.C. side		—	—	—	—	—
1.453 Harmonics of A.C.	—	—	Not yet sufficiently known		—	—	—	—	—
1.453 Undulation of rectified D.C.	—	—			—	—	—	—	—

ower units.

Japanese National Railways			*Netherlands Railways*		*Norwegian State Railways*	*South African Railways*		*Swedish State Railways*		*U.S.S.R.*	*Victorian Government Railways*	
D.C. 1.5	A.C. 20	A.C. 20	D.C. 1.5	D.C. 1.5	A.C. 15	D.C. 3	D.C. 3	A.C. 15	A.C. 15	A.C. 25	D.C. 1.5	D.C. 1.5
L	MU	L	MU	L	L	MU	L	MU	L	L	MU	L
1 150 to 1 880	10 to 47	70 to 150	400 to 800 per unit	1 560 to 2 340	approx. 200	140 to 160 per unit	153 to 260	75 rail bus ~ 15	145 to 290	210	720 to 1 080	1 260
—	D.C. motors A.C. commutator and induction motors. Ignitron, Exitron Silicon rectifiers		—	—	A.C. commutator motors	—	—	A.C. commutator motors		Motors for pulsed D.C. Ignition rectifiers	—	—
—	Provided : Two resonant circuits on A.C. side; choke on D.C. side		—	—	—	—	—	—	—	Two reactors one for each group of three parallel motors	—	—
—	— Low for A.C. motors	$1/n^2$ to $3/n^2$	—	—	small	—	—	very low, little noise induction		See text	—	—
—	—	10 % to 30 % depending on type	—	—	—	—	—	—	—	Current 25 % Voltage 50 %	—	—

the amount of noise that may be experienced on the telecommunications side.

The replies to question 1.46 asking what value of current is used for calculating interference effects under normal and abnormal traction conditions is of considerable significance as it is at present an open question as to whether the present C.C.I.T.T. Regulations do or do not adequately represent the facts. Because the current in the overhead contact line is varying throughout its length and from time to time, it is clearly a matter of difficulty to state it clearly and precisely and thus decide in advance, as is necessary, what measures should be taken for avoiding interference from electro-magnetic induction for a new project. The present C.C.I.T.T. Regulations, which are understood to be in process of revision, are as follows :

" 289. 2. Normal working. *a*) In normal working the maximum induction effect produced on a telephone line must be determined. This maximum is obtained when the loading conditions are most unfavourable. It is considered that the condition is most unfavourable when the current in the traction line section is that taken by two large locomotives at the extremity of the section. In the case of a railway with several rails, the most unfavourable condition is 1.5 times the current thus defined.

290 When the alternating current traction line has several feeding points, the currents taken by the locomotives and flowing in the different parts of the traction lines can be in opposite directions. Consequently the effects of induction on parallel telephone lines extending through several sections can tend to cancel out if the traffic is sufficiently heavy. Where the traction line is supplied in independent sections the total length of the telephone line is not subjected to an induced effect greater than that caused by the section which exerts the greatest influence. It is sufficient therefore to consider each section separately.

291 Where the substations are operated in parallel, the compensating effects of the locomotive currents can be important. However, the currents may circulate between the substations in such a way that it may become necessary to take into account the effect of the difference between the currents in each direction, that is the current which is not compensated for. The inductive effect of the non-compensated current can, in the case of a long parallelism, be of the same order as that caused by the locomotive currents in a working section. The case should also be mentioned where, owing to special conditions, the traction line is divided into sections for certain periods. At the time the proposed parallelism with a traction line thus fed is examined, the effect of induction exercised by each of the working sections should be considered as in the case of sectioned lines.

292 To estimate if the parallelism is permissible, only the supply section which gives rise to the greatest induced longitudinal electro-motive force is taken into consideration."

The replies received to this question and to the following question 1.471 asking for the value of short circuit current used in calculating whether the interference is within the permitted limits, mentioned in Chapter III, are summarised below.

The answer from the Indian Railways relates only to the scheme about to be brought into service from Durgapur to Moghalsarai. For this section of the line, the reply was that 600 amps is used for calculation under normal conditions and 3 000 amps under fault conditions, and by reference to Table 4 it would appear that the normal value is considerably in excess of the current due to two locomotives mentioned in the C.C.I.T.T. Regulations, which would be approximately 290 amps $\times$ 1.5 = 435 amps.

The Japanese Railways' reply is that the current assumed normally is based upon the

train schedule, averaged at 100 amps per train and that the normal value of induction is calculated on the basis of 400 amps which again appears to be in excess of the C.C.I.T.T. stipulation, but in this case, as in the case of the Indian Railways, the distance over which this current is assumed to flow in the overhead contact system is not stated. The current under abnormal (fault) conditions is stated as 1 500 amps to which a note is added that the source impedance is very high, the fault level at the input being only 100 M.V.A.

The Norwegian Railways base their calculations at 200 to 300 amps normally and 600 amps under fault conditions, the former value appears to be less than that stipulated in the existing C.C.I.T.T. rule.

Swedish Railways base their normal current on the tripping value of the circuit breakers, (which is stated to vary between 500 and 600 amps) which appears to fit in with the value stipulated in the rule. As however circuit breakers will only open infrequently under normal overload, the basis of the Swedish calculations appears to be cautious. The current value mentioned above is also used as a basis for dimensioning the booster transformers, because even a moderate increase of the load current exceeding this value due to magnetic saturation of the booster transformers will result in a great increase of the interference effects. On such a large network as that of Sweden, the circumstances as regards fault currents clearly vary and in their reply the figure of 1 200 amps is quoted as the most unfavourable.

The reply of the Russian Railways on this matter is uncertain, whilst British Railways propose to base their calculations under normal circumstances on a value which arises from a study of the timetable and the current under fault conditions from a study of the fault level on the particular section involved.

In view of these replies, it is clear that further investigation and decision is required to establish a firm basis on which the interfering effects arising from a particular electrification can be calculated.

1.5. Compensating factors.

This general title is used for a series of questions concerning the arrangement of the overhead traction lines and any measures incorporated (more particularly in the A.C. case) for reducing the interference effect. The general arrangement of the overhead lines is described in the particulars given in Table 5 along with particulars of the rails and their bonding. Concerned as they are with rails which differ in gauge from 1.0 to 1.67 m, and differing widely in their characteristics, the replies show a wide diversity of arrangements which it is difficult to summarise.

Whether railways are electrified on the D.C. or A.C. system, the running rails form an important compensating factor. In the latter case, however, the replies show that a number of Administrations use either booster tranformers with or without return conductors, as an important element of compensation on the traction side.

Rails as a rule are not specially earthed although they are, of course, connected in substations to an « earthy » busbar. The method of bonding the rails, which, except in the cases where a return conductor is used are employed for the return of current to the substation, depends upon the system of track circuiting as does the method of bonding the structures carrying the overhead line. Where single rail track circuits are used, structures are generally connected direct to the rail, but with double rail track circuits such connections are only permitted at the mid points of impedance bonds and individual structures are connected to an earth wire.

The extent to which these compensating factors are effective can be judged from the answers given to questions 1.516 and 1.519 to which some replies are given in Table 5.

TABLE 5. — Partic

Railway Administration : *Question*		*British Railways*	*Indian State Railways*		*Japanese Na* *Railways*
1.51 Track gauge in metres. . . .		1.435	1.676	1.000	1.067
1.51 Distance between track centres in metres		3.35	4.724 (4.27 - 5.49)	4.420	3.6 to 4.0
1.511 Number of rails used for return current.		Average 1.5 per track.	Mostly 2, sometimes 1 per track.	2 per track	Between stat 2 per track. In stations : 2 or 1 per t
1.511 Intervals in metres for cross-bonding	*between rails of one track*	Intervals determined by track circuits	Approx. 50 to 300 one line 1 600	No cross bonds with metal sleepers. Approx. 350 with wooden sleepers	—
	between tracks		90		—
1.512 Rail dimensions given in kilogram per metre	*new*	47, 49 and 55	45, 50 and 58	38	30, 37 and
	with maximum wear	41, 43 and 48	43, 47.5 and 55	35	24, 30 and (for main l
1.513 Longitudinal bonds		Copper bonds, D.C.: less than 0.9 m rail. A.C.: 10 m rail.	Depends on signalling requirements Copper bonds, varied dimensions.		Copper bonc to 140 sq. 1.5 to 0 length.

d rails.

herlands ilways	*Norwegian State Railways*	*South African Railways*	*Swedish State Railways*	*U.S.S.R.*	*Victorian Government Railways*
.435	1.435	1.067	1.435	1.524	1.600
to 4.0	4.25	3.96	4.5 (min. 4.25)	min. 4.1 to 5.0	3.96 old lines 3.56
t 2 rails per ine.	Normally all rails.	1 rail per track.	All available rails.	Outside stations practically all rails.	Generally all rails.
tervals ermined by rack rcuits	—	Approx. 335 except where track circuits are used.	Approx. 2 500 except where track circuits are used.	800 to 2 700	—
	—	Approx. 335	Approx. 2 500 One rail per track only, when track circuits are used.	2 500 to 8 100	Suburban : 450 to 750. Country : 900 to 1 500.
47	35, 49	30, 40 and 48	43 and 50	43 to 75	47 and 54
39	—	26, 35 and 40	42 and 48.5	39 to 67	39 and 45
bonds, less 2 m rail.	Copper bonds, approx. equal to 2 m rail.	Copper bonds, less than 0.9 m rail.	Various types : ∠ 0.1 ohm for 2 km rail.	Copper bonds, less than 3 m rail.	Copper bonds.

TABLE 5. — Pa

Railway Administration : *Question*		British Railways	Indian State Railways		Japanese Na Railway
1.514 Contact line masts	*Material*	Generally steel	Mainly steel.	Steel.	Mostly reinf concrete, s times steel.
	Earthing arrangements	Connected to rails, individually or by means of « earth wire ».	Connected to rails, solidly or via spark gap.	Connected by continuous wire earthed every 400 m.	See text
1.516 Impedance of the circuit rails/earth in ohms/kilometre	*at fundamental frequency*	$0.5 \angle 79^\circ$ to $0.66 \angle 73^\circ$	D.C. 2 rails approx. 0.016	—	See text
	at 800 c/s	Not yet known.	—	—	See text
1.517 Leakage resistivity rail to earth in ohms/kilometre		1 to 100, average 5, for one rail.	A.C. line 0.6 to 3, average 2.5 per track.	—	0.5 to 5 —
1.518 Voltage between rail and earth	*normal working condition*	Not yet sufficiently known.	$\left.\begin{array}{c}0.08 \text{ to } 0.26\\ \times\\ 300 \text{ to } 400\end{array}\right\}$ A.C.	max. 75	A.C. 20 to D.C. 160 t
	during a short-circuit	Not yet sufficiently known.	$\left.\begin{array}{c}0.08 \text{ to } 0.26\\ \times\\ 1\,000 \text{ to } 3\,000\end{array}\right\}$ A.C.	—	A.C. 150 t
1.519 Impedance of the supply circuit : contact wire/rails and earth in ohms/kilometre . . .		Single: $0.54 \angle 71^\circ$ Track: $0.49 \angle 72^\circ$ Two: $0.33 \angle 73^\circ$ Tracks: $0.29 \angle 75^\circ$	Single track : $0.49 \angle 70^\circ$ Double track : $0.30 \angle 70^\circ$ (A.C.)	0.06 (D.C.)	Approx. 0.6 at 50 c 7.0 at 800

s and rails. *(continued).*

therlands ailways	*Norwegian State Railways*	*South African Railways*	*Swedish State Railways*	*U.S.S.R.*	*Victorian Government Railways*
nd prestres- concrete.	Wood or concrete.	Steel.	Mostly steel, sometimes concrete.	Steel or reinforced concrete.	Mostly steel.
cted to rails ark gap in f automat. ing.	—	Connected to rails, solidly or via spark gap.	Connected to one rail.	Connected to return rail, solidly or via spark gap.	Connected to rail via spark gap.
—	0.12 $\angle$ 55° (16 2/3 c/s)	0.04 per rail (D.C.)	2 rails parallel 0.29 $\angle$ 61° mean value for 90 to 300 amps.	Single track: 0.56 $\angle$ 70° Double track: 0.44 $\angle$ 74° } 50 c/s	—
—	6.7 $\angle$ 86°	—	6.9 $\angle$ 72°	(single track) 7.9 $\angle$ 71°	—
—	0.33 to 0.9	—	50 to 0.35 with masts. Rails alone 2 500 to 7.	Minimum 0.25	3 to 15
to 80	—	—	50 to 100 estimated maximum values	30 to 50 with frozen soil to 100	up to 40 abnormally up to 90
—	—	—	—	—	up to 150
track : ance : nH/km.	0.33 $\angle$ 47°30' (16 2/3 c/s) refers probably to question *1.532.*	0.085 to 1.1 mean 0.41	0.26 $\angle$ 43°30' measured	Single track : 0.52 $\angle$ 65° Two tracks : 0.34 $\angle$ 71° — measured : 0.465 $\angle$ 64° for single track.	—

The Japanese National Railways deal with 1.516 in considerable detail in a statement giving the values they calculate, which is too long for inclusion in the table. The values take into account the size of the rails (30 to 50 kg/m), the current in the rails (100 to 500 amps), the frequency (whether 50 or 60 cycles) and the soil resistivity for values of 10^3, 10^4 and 10^5 Ω cm. The reply shows that as the impedance is mainly reactive with phase angles of 70 to 80°, the size of the rails has little effect, modifying the result by only 5 % to 6 %. Presumably because of skin effects, the effect of heavy currents is bigger with a lighter than with a heavier rail and both resistance and reactance increase with increasing current. Increase of the soil resistivity modifies only the reactance, increase of frequency increases resistance and reactance. The lowest value given is:

$0.114 + j\,0.497 = 0.510 \angle 77°5'$ for 50 kg/m, 50 c/s, 100 amps, 10^3 Ω cm;

The highest value is:

$0.248 + j\,0.828 = 0.865 \angle 73°19'$ for 30 kg/m, 60 c/s, 500 amps, 10^5 Ω cm.

At 800 c/s, the lowest and highest values are:

$1.094 + j\,5.875 = 5.93 \angle 79°\,27'$ for 30 kg/m and 10^3 Ω cm, and $0.968 + j\,7.944 = 8.00 \angle 83°3'$ for 50 kg/m and 10^5 Ω cm.

For D.C. traction, where the rails are used for the return of current, the only compensating effect is where the filters are fitted to reduce the harmonic content of the electrified current, to which reference has already been made.

For A.C. traction most of the Railways with which this report deals use booster transformers and return conductors to reduce the interference from the current in the overhead contact line. Booster transformers are used by Norway and Sweden, and by Japan, and are proposed to be used to a considerable extent on British Railways. The methods used are shown in Table 6.

Figure 2 shows the fundamental methods in which the booster transformers are connected with and without a special return conductor taking into account the type of track circuit used. Spacing of the booster transformers given in Table 6 must depend very much on local circumstances as will the size of the transformer and its other electrical characteristics.

For these reasons, it is difficult to generalise on the extent to which electromagnetic induction is reduced by the use of booster transformers with or without return conductors. This will vary with the harmonic content of the current and be different under normal load conditions and under fault conditions.

The replies to questions 2.11 to 2.13 given in Chapter II record the information which has been given regarding this reduction. Table 6 gives the replies to questions 1.522.1 and 1.522.3, namely, no load currents at varying voltages and the magnetising current at 800 c.p.s. but it does not give the answers to question 1.522.2 as to the harmonic content or the equivalent disturbing value of the no load current. These questions are of importance because the booster transformers will, to some extent, distort the line current and may thus introduce additional noise into the telecommunication circuits.

The equivalent disturbing current is a measure of this possibility and is defined in the C.C.I.T.T. directive as:

$$\frac{1}{p_{800}} \sqrt{\sum (h_f p_f I_f)^2}$$

In this expression:

I_f is the component at frequency f of the current causing the disturbance;

p_f the weight attributed to this frequency;

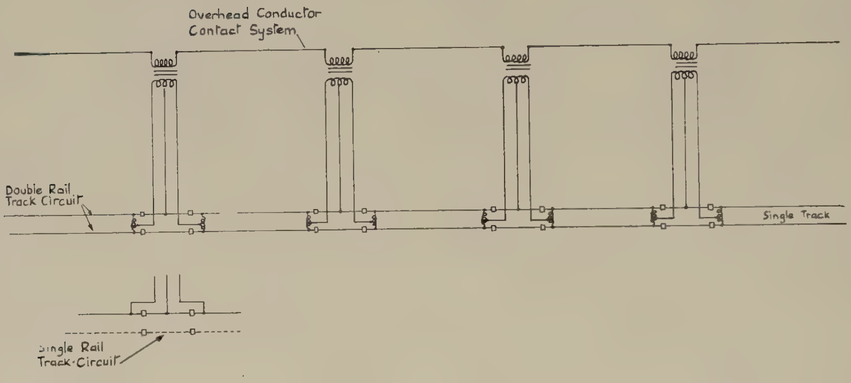
h_f a factor, which is a function of the frequency, which takes into account the type of coupling between the lines concerned.

By convention the value of h at frequency 800 c/s, (h_{800}) is taken as 1.

Railway Administration : *Question*	*British Railways*	*Japanese National Railways*	*Norwegian State Railways*	*Swedish State Railways*
1.521.2 Booster transformers are connected to ?	Generally to a special return conductor; some to running rails.	To return conductor; this is connected to rails at impedance bonds.	Connected to running rails.	Generally to a special return conductor; two lines (106 km) to running rails.
1.521.1 Spacing in kilometres . — mean	return conductor 3 return rail 1.5	3.9	2.8	return conductor 5.0 return rail 2,8
1.521.1 Spacing in kilometres . — maximum	return conductor 4 return rail 2	5.5	3.0	return conductor 6.0 return rail 3.1
1.522.1 Voltage for a no-load current of . . . — 2 amps	820 | 1 400 | 1 550 | 2 000	530 | 580	Approx. 200	425 | 465
1.522.1 Voltage for a no-load current of . . . — 10 amps	1 100 | 1 980 | 2 400 | 2 900	780 | 840	400	670 | 760
1.522.3 Magnetizing current at 30 V, 800 c/s in milliamps	20 to 30	Approx. 20 to 50	—	20
1.531 Size and position of return conductors, if used	Only in connection with booster transformers. 58 to 143 sq. mm copper, approx. 3.0 m from contact wire, 0.6 m above.	Only in connection with booster transformers. Normally 125 sq. mm copper in tunnels, otherwise 180 or 215 sq. mm Aluminium, approx. 3.0 m from contact wire, 1.0 m above.	None.	Only in connection with booster transformers. 130 sq. mm copper or 212 sq. mm Alum. approx. 2.6 m from contact wire, 0.7 m above.
1.532 Impedance of the traction loop in ohms/kilometre	Approx. 0.7 ∠ 74° to 0.92 ∠ 58° during normal operation for booster transformers with return conductor, at 25 kV.	Normal (calculated) 0.89 ∠ 66°. With short-circuit down to 0.63 ∠ 69°.	See answer to *1.519*	0.36 ∠ 39° with return conductor. 0.31 ∠ 42° with return by rail.

BOOSTER TRANSFORMER CONNECTIONS

a) *with rail return:*



b) *with special return conductor:*

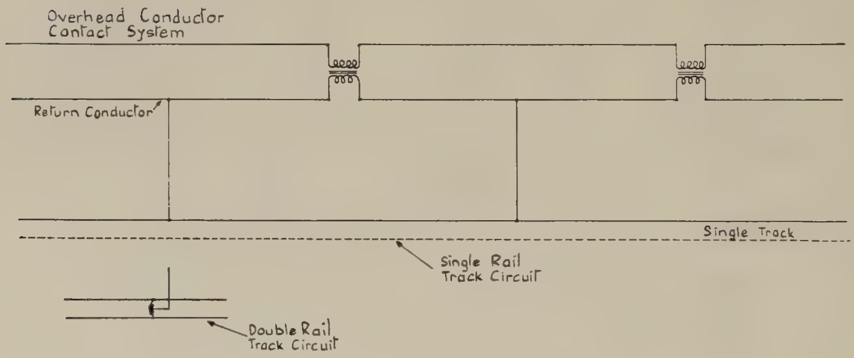


Fig. 2.

This equivalent disturbing current corresponds to a current at a frequency of 800 c/s, which flowing in the power line, would produce the same disturbance upon a neighbouring telephone line as the service current.

The often used values of h_f, namely, $f/800$ and 1, are abbreviated by $\times f$ and $\times 1$ respectively.

The replies to question 1.522.2 did not in all cases permit the determination of the value of the equivalent disturbing current because insufficient details of the harmonics involved were given. The following table records the values given by British Railways and by Japan, both using 50 c.p.s. and Sweden 16 $^2/_3$ c.p.s. and has been extrapolated from the data given in the replies to make comparison easier.

Equivalent disturbing current, in amps, of the no-load current, in amps. of booster transformers.

No load current	*British Railways 50 c/s*		*Japanese National Railways 50 c/s*				*Sweden, 16 2/3 c/s*	
	Transf. 25 kV 150 A, 45 kVA	*Transf. 6.25 kV 200 A, 80 kVA*	*Transf. 36 kVA* $\times 1$	*Transf. 36 kVA* $\times f$	*Transf. 64 kVA* $\times 1$	*Transf. 64 kVA* $\times f$	$\times 1$	$\times f$
1.0	0.01	0.01	0.007	0.002	—	—	0.0005	0.0002
1.5	0.03	0.03	0.01	0.004	0.0005	—	0.0013	0.0005
2.0	0.06	0.053	0.021	0.006	0.002	—	0.002	0.0007
3.0	0.15	0.03	0.03	0.003	0.01	—	0.004	0.0012
5.0	0.30	0.16	0.06	0.016	0.05	0.003	0.007	0.0022
7.0	0.40	0.20	0.08	0.023	0.10	0.015	0.010	0.0032
10	0.48	0.25	0.11	0.025	0.15	0.028	0.016	0.0048
20	0.68	0.34	0.17	0.049	1.4	0.49	0.024	0.009
30	0.78	0.40	0.21	0.062	2.0	0.67	0.032	0.012
50	—	—	—	—	2.8	0.91	—	—
100	—	—	—	—	4.3	1.3	—	—
200	—	—	—	—	6.9	2.0	—	—
300	—	—	—	—	9.2	2.6	—	—

The upper half of the table refers to the values under normal operating conditions when the no load current is small. The lower part of the table gives, where they are available, figures corresponding to the currents obtaining under short circuit conditions.

The table shows that the amount of distortion increases as the no load current increases up to a point but then begins to decrease again. The values of the equivalent disturbing current with the additional factor $f/800$ are always lower, about one third, of the values without this factor because the main harmonics considered are below 800 c.p.s.

The no load current and its distortion may have some interfering effect also for rather small current values, as this current does not pass through the secondary circuit of the booster transformers (rails or return conductor) but through earth instead.

From the answer to question 1.453 (Table 4) given by the Japanese Railways of harmonics produced by locomotives with D.C. motors, the corresponding equivalent disturbing current can be determined. If the load current is 400 amps, as given in the reply to question 1.46, the equivalent disturbing current will be 7 - 21 amps for $h_f = 1$ and 5 - 15 amps for $h_f = f/800$. In Sweden, the maximum equivalent disturbing

current in the contact line is measured to 1 amp for locomotives with A.C. motors. Without booster transformers, a great part of this current would pass through earth but, by means of such transformers, almost all this current will pass through the rails or the return conductor, thus compensating the contact line current more or less completely due to existing circumstances.

The answers to question 1.542 mention in most cases devices considered in earlier questions. U.S.S.R. suggest the use of attenuating circuits in substations which could dissipate the energy of electric oscillations produced by rectifiers on locomotives. Such circuits would be provided by a capacitor and a resistor connected in series between busbar and earth. Appropriate values for the capacitors are suggested: approx. 2 - 2.25 μF, with 40 - 50 Ω for a double track or 15 - 25 Ω for a single track line of length 25 - 30 km.

The information given in reply to question 1.55 asking for experience regarding the advantages and disadvantages of these compensating devices from the point of view of traction is rather scanty. U.S.S.R. say that the basic measure should be cabling of telecommunication lines using cables with appropriate screening factor.

For D.C. traction, the only method of compensation considered is the provision of smoothing filters in rectifier substations. The South African Railways emphasise that they have no advantage from the traction point of view, but several disadvantages. Extra costs, extra maintenance and the risk of trouble if a capacitor breaks down. India has no adverse comments to make.

For A.C. traction, the main method considered is the use of booster transformers. Their disadvantages, from the point of view of traction, are increase in initial and running costs, due to losses, particularly in the return conductor, and a higher voltage drop (British Railways, Japan, Sweden). Maintenance becomes more difficult (Japan, Norway); an earthed conductor near the contact wire is undesirable (Japan). The justification for their use is that alterations in telecommunication installations otherwise required would be still more expensive (Japan: the initial savings on the Hokuriki Line is stated to be about 180 million yen per kilometre), and in the British case that the Post Office were unable to alter their system within the time available, quite apart from the fact that the cost of doing so seemed likely to exceed the cost of compensating interference at the source. However, there are some incidental advantages for traction, particularly if a special return conductor is used. The reduction of the rail current permits the use of simpler track circuits and, sometimes, to dispose of electrical bonds. The return conductor improves the earthing conditions of the structures with regard to lightning, even if it is connected to the structure over a spark-gap only.

In addition, Japan notes that filters installed on A.C. locomotives to reduce harmonics in the supply are fairly effective as surge absorbers.

CHAPTER II.

Resulting interfering effects.

These effects depend, inter alia, of course on the inductive coupling between the contact line and the signalling and telecommunication lines. This coupling is very sensitive to the value of soil resistivity. The effects also depend on the compensating and screening factors with which this chapter is mainly concerned.

Question 1.48 asked for particulars of the electrical resistivity of the earth and what geological formations are normally to be found on the electrified lines. It requested particulars of any tests carried out to determine the value of resistivity which should be used for interference calculations, and the methods used for making these tests. It concluded by asking for values which, in the absence of tests, have been based on the experience of others and are considered to be the most appropriate.

The following railways have no data to contribute on this matter: Netherlands, New Zealand, and Victoria, although the latter stated that they based their calculations on values varying from 5 000 to 10 000 Ω cm, resulting from tests made by the State Electricity Commission.

The Indian Railways' reply indicated the wide variations experienced ranging from 500 to 25 000 Ω cm, the values being obtained from measurements made by the Indian Post Office.

The Japanese Railways made measurements for each individual case and provided a map showing soil resistivity at a variety of points. The value was measured either by Wenner's four electrode method or derived from measurements of the inductance treating the earth resistance as a variable. The values range from 80 to 40 000 Ω cm.

Norway gave a value of 230 000 Ω cm. Sweden also gave a resistivity map deduced from a geological map and checked by measurements of mutual inductance and made by WENNER's method showing that the largest part of Sweden comprising the granite and the gneiss area has an average value of 200 000 Ω cm whilst in the southern part of Sweden, the value is as low as 2 000 Ω cm.

Russia gives values based upon Wenner's method varying from 1 000 to 200 000 Ω cm and determines an average value for each section of the railway.

Great Britain uses the values obtained from a soil resistivity map prepared by the Electrical Research Association, reference MT/32 & 33 dated 1935, for preliminary calculations and proposes to check these in the course of a series of tests which are about to commence.

The proper value of soil resistivity to use is difficult to determine because the depth of penetration of earth currents depends upon the frequency in addition to varying considerably, even in a small country, from one part of an electrified line to another. Results of tests made near the surface of the earth as, for example, by WENNER's method, may therefore be misleading, but on the other hand, to treat the resistivity as a variable, which can be derived from actual measurements of self or mutual inductance at appropriate frequencies using CARSON-POLLACZEK's formulae, is made difficult because of the effect of compensating earthed conductors such as the railway tracks themselves, cable sheaths and other buried metal, such as pipe-lines.

The difficulty of measuring compensating effects becomes obvious from the answers to questions 2.11 and 2.13 which do not lend themselves to inclusion in the tables. Question 2.11 asked for the values of the currents in all relevant screening conductors (as a percentage of the maximum load current and of the fault current) expressed vectorially. Very few measured data on currents in rails, cable sheaths, etc. have been given, still less values of the phase angles.

The railways with D.C. traction have given no information at all on screening even for harmonics; South Africa assumes that 100 % current returns by the rail.

For railways with A.C. traction the screening factor of rails (without booster transformers) is given by U.S.S.R. as 0.4 to 0.6, depending on the number of tracks.

The following particulars are given by railways which use booster transformers:

With rail returns, the average rail current in Norway is 98 % $\angle$ 180° for 200 amps traction current. The cable sheath current is given as 1.5 % $\angle$ 6°30′, indicating overcompensation due to induction by the rail current. In Sweden the average rail current is 96 %, the minimum 94 %, both with a phase angle of 180°. Norway gives no information about these currents under fault conditions whilst Sweden mentions the effects of the saturation of the booster transformers, which depend on the intensity of the short-circuit current and thus on the distance between fault and feeder station; saturation becomes significant with more than 1 500 amps.

When booster transformers are used with return conductors, Sweden states that under normal conditions the compensation is nearly perfect, thus rail and sheath currents will be small. With 1 200 amps short-circuit current (fault about midway in a supply section), the rail current will be about 200 amps $\angle$ 160° and the earth return current also 200 amps. The compensation is as good for harmonics as for normal traction currents. British Railways have not yet sufficient measured data available to reply to the question.

Japan gives the following calculated values of current sharing between return conductor associated with booster transformers, the rails and cables, (*a*) on the surface of the soil and (*b*) on overhead cable :

Condition : Frequency Soil resistivity ohms centimetre	*Normal operation 50 c/s*		*Short-circuit 50 c/s*	
	1 000	100 000	1 000	100 000
(*1*) *Contact wire current* *amps*	400 $\angle$ 0°	400 $\angle$ 0°	1 000 $\angle$ 0°	1 000 $\angle$ 0°
(*2*) *Return conductor current amps*	388 $\angle$ 180°	386 $\angle$ 186°3′	728 $\angle$ 181°12′	736 $\angle$ 180°31′
(*3*) *Rail current* *amps*	15.9 $\angle$ 188°59′	15.9 $\angle$ 187°35′	144 $\angle$ 183°32′	165 $\angle$ 184°14′
(*4*) *Sheath current* (*a*) *amps*	2.4 $\angle$ 207°44′	2.5 $\angle$ 200°54′	15.0 $\angle$ 195°16′	16.3 $\angle$ 197°29′
(*5*) *Sheath current* (*b*) *amps*	8.3 $\angle$ 242°2′	7.9 $\angle$ 235°35′	39.2 $\angle$ 231°47′	43.2 $\angle$ 227°13′
(*6*) *Vectorial sum of amps.* (*2*), (*3*), (*4*), (*5*)	409.8 $\angle$ 181°20′	407.6 $\angle$ 181°20′	911.1 $\angle$ 183°41′	947.1 $\angle$ 183°21′
(*7*) *Earth current*	14.6 $\angle$ 48°20′	13.1 $\angle$ 49°	107.2 $\angle$ 146°42′	77.6 $\angle$ 134°29′

The only specific answer to question 2.13, asking for the equivalent disturbing current is that of Japan who give the following calculated values for an equivalent disturbing current in the contact wire of 20.7 amps, namely :

Return conductor : 20.1 amps. Rail 0.82 amps. Sheath of cable (*a*) 0.14 amps. Sheath of cable (*b*) 0.97 amps.

The next questions, 2.14 and 2.15 are of importance only when open wire lines may experience electrostatic induction. They ask for values of the product of rated voltage and relevant electrostatic screening factors (2.14) and equivalent disturbing voltage and relevant electrostatic screening factors (2.15).

Detailed information is only given by the Japanese Railways; it may not have been generally realised that 2.15 refers to A.C. and, because of the electric field of harmonic voltage, to D.C. traction, but Japan states that it is important for D.C. railways only, with open wire telecommunications.

The screening factor for an earthed conductor is given as 0.9 by Japan, for the two return conductors of a double track railway as 0.8 by British Railways. Screening by trees or track in a cut gives factor 0.8 (Japan). For D.C. traction, Japan aims at an equivalent disturbing voltage of not more than 2 V, to which the factors 0.9 and 0.8 must be applied.

Arrangement of signalling and telecommunication circuits and their protection.

The next series of questions 2.21 to 2.213 ask for particulars of the arrangement and of the protection of signalling and of public as well as railway telecommunicaion lines. With one exception, Sweden, the replies relate only to the railway circuits and are analysed in Table 7. Netherlands, New Zealand and Norwegian Railways did not reply to these questions.

The diverse replies received to questions relating to the physical arrangement of these circuits on railways electrified on the D.C. system no doubt reflect the geographical conditions available on the route whilst the only case in which open lines are used in A.C. electrification (U.S.S.R.) is characterised by a high separation from the nearest overhead contact line. Where they are used, the lines are always transposed. Frequent transpositions such as those mentioned by the Indian State Railways and the South African Railways will have been enforced to avoid cross-talk when carrier frequency is used. It does not appear from the answers that special transpositions are additionally necessary, e.g. to avoid noise, but in Japan it has sometimes been necessary to double the number of transpositions. The only use of single wire circuits is for telegraphic circuits on D.C. sections of the U.S.S.R. and the reply to question 2.212.6 states that no special devices are found to be necessary.

Measured values of the sensitivity coefficient are reported by five Administrations, as mentioned in Table 7, but the Victorian Government Railways' measurements are still in hand and results are not yet available. The question asked whether tests have been made to determine this coefficient (which is defined as the ratio between the transverse e.m.f. induced in the loop, due to assymetries in relation to earth and adjacent conductors, and the longitudinal e.m.f.) on a statistical basis. None of the answers give a reply on a statistical basis. In answering this question the Japanese Railways quote values of the noise balance of 20 to 70 db. which corresponds to a sensitivity coefficient of 0.1 to 0.0003. (In addition, they give values of the circuit balance measured with a frequency of 1 000 c.p.s. as 20 to 75 db.) They state that most circuits have values lying between 50 and 55 db. Such values correspond to sensitivity coefficients of .003 to .002.

Seasonal variations have not been observed but daily variations of less than 10 db. are mentioned as occurring during the night. South African Railways have measured a sensitivity coefficient of 0.0015 for a well transposed route and note in their reply that the methods of the transposition, the length of the exposure and the T.I.F. (telephone influence factor) need to be taken into account to determine the resultant noise. The coefficient may be ten times larger for an imperfectly transposed route.

Only Sweden and Russia both give values of the sensitivity coefficient for copper and iron wires. Sweden quotes a maximum value of .004 for copper and .01 for iron. U.S.S.R. gives ranges as .005 to .01 for copper and .003 to .006 for iron. Both countries experience variations due to weather, the values in winter and summer being lower in Russia than those in the spring and in the autumn.

Sweden gives a formula for a minimum distance between public telephone lines and railways: If l is the length of the exposure in kilometres, the separation from a railway with booster transformers and rail return should be more than $200\sqrt{l}$ m; if the booster transformers have an insulated return conductor, this minimum separation is $80\sqrt{l}$ m.

2.22. Cables.

This series of questions relates to the arrangement of cabling signalling and

TABLE 7. — Arrange

Railway Administration : *Question*	*British Railways*		*Indian State Railways*		*Japanese Nati Railways*	
D.C. or A.C. traction . . .	D.C.	A.C.	D.C.	A.C.	D.C.	A
2.211 *Separation from nearest rail in metres . . . .*	3.0	—	Minimum separation height of pole + 1.3 for broad gauge; + 1.5 for 1 m gauge	—	Min. 4 Mean 7 (if no filters are provided, 5 times these values)	
2.212.1 *Heights above ground in metres* — *Min.*	3.0		3.4		2.5	depends locatio f.e. acr road railway
2.212.1 *Heights above ground in metres* — *Max.*	9.2		8.5		10	
2.212.2 *Maximum transverse dimensions in metres . . . . . .*	1.1		2.1		2.8	
2.212.3 *Distance between conductors in metres . . . .*	0.30		Pairs : 0.20 0.27 0.30 Quads not used.		Voice circuit 0.3. Carrier circuit 0.2	
2.212.4 *Transposition steps in metres*	Simple transpositions are used.		Transpositions as used by Bell Tel. Co. 30 to 128 transpositions per 8 miles.		Standard transp scheme; number o positions per mi given.	
2.213.1 *Sensitivity coefficient measured ? . . . .*	No.		No.		Yes.	

lines.

South African Railways	*Swedish State Railways*		*U.S.S.R.*		*Victorian Government Railways*
D.C.	D.C.	A.C.	D.C.	A. C.	D.C.
his is normal average, nimum for long expo- For short exposures, ım height of pole	No open wire railway lines along electrified railways. Minimum separation of public telephone lines depends on length and booster transformer arrangement.		10 to 20 or more	100 for short lines. 3 000 to 5 000 for long lines.	Minimum : 4.9 Mean : 10.7 Maximum : 18.3
sometimes higher at crossings	—		2.5		3.2
			depends on local conditions		6.1
2.0	—		Maximum at cross bar 2.4, on profile (?) 3 to 3.5.		1.8
20. not used.	—		Pairs 0.20 to 0.60 Quads not used.		0.23
ɔlder lines have rota- ew lines « point type » sitions, depending on · and frequency range ·ier channels. Trans- ıs occur, thus, on every · 28 poles/mile, corres- g to Bell scheme.	Normally 1/4 rotation for each pole. Rotations are regularly omitted to avoid cross talk.		Transposition step 100 m to 6.4 km, depending on conditions. Method : pair rotation.		Standard transpositions for 3 channel carrier circuits.
Yes.	Yes.		Yes.		Yes.

TABLE 8. — Arra

Railway Administration : Question				*British Railways*	*Indian State Railways*	*Japanese National Railways* D.C.	A.C.
2.221	*Method of installation of cables*			Armoured cables on concrete stumps or in concrete troughing.	Normally underground.	Signalling cables: overhead or in trough if many, or buried if one cable. Telecom. cables, old installation : overhead in trough, new installation : buried.	Signalling c as for D.C. com. cables ried, if pos otherwise trough.
2.222	*Overhead cables. Position, distance from contact wire in metres*			Not used.	Not used.	7 m from contact wire; minimum clearance 2 m.	Not use
2.223	*Other cables*	*Distance from nearest rail in metres*		2.0	Approx. 4.0	—	Sign. appro Telecom. 3
		Height over rails in metres		Variable; generally less than 1.	— 0.8	—	Signall. 0.6 below g level ; troug ground. Tele below groun
2.224.1	*Cables with metallic sheath*	*Core insulation*		Paper; d.c. signal cables oil impregnation.	Signalling: impregnated paper. Telecom. : paper.	Signalling : Vinyl Telecommunication new : as a.c. old : paper.	air/polythen or solid pol

therlands ailways	*New Zealand Railways*	*Norwegian Satte Railways*	*South African Railways*	*Swedish State Railways*	*U.S.S.R.*	*Victorian Government Railways*
cables; even w kilometres l electrified	Mainly in concrete troughing; ducts for short distances.	Buried cables.	Generally buried, or in non-metallic pipes.	Underground cables on all A.C. lines.	Underground cables preferred.	All methods used; generally fibrolite or sheet steel troughing.
ot used.	Not used.	Not used.	Not used.	Not used.	Not used.	Stainless steel sheathed self supporting cable, 4 m f.c.w. Neoprene cable on earthed steel carrier, 7.5 m. Polythen cable on earthed steel carrier, 3.6 m.
min. 3	min. 1.8	Railw. c. 1.4. Com. c. : 12 or more.	Between tracks: 1.5. Outside : 10 to 12.	1.2	Position determined by calculation.	Approx. 3
— 1	Variable.	Railw. c. – 0.4	– 0.75 or more	– 0.7		0.45
ing : egn. paper; C. one : r; then .	Paper.	Star quads, paper and plastic.	Star quads, paper.	Paper.	Paper or styroflex.	Paper.

TABLE 8. — Arra

Railway Administration : Question			*British Railways*	*Indian State Railways*	*Japanese National Railways* D.C.	A.C.
2.224.1	*Cables with metallic sheath (continued).*	*Sheath*	d.c. : lead a.c. : aluminium or lead, copper reinforced.	Lead alloy.	Signalling : Vinyl Telecommunication : new : as a.c. old : lead	Polyther or Vinyl
		Armouring	d.c. : steel wires. a.c. : steel tapes, at least with heavy traffic	Steel wires or tapes.	Signalling : 2 steel tapes Telecommunication : 2 steel tapes.	2 steel tap
		Protection against corrosion	d.c. cables earthed at one point only.	—	Signalling : Vinyl Telecommunication : Lead sheath has P.V.C. cover	none
2.224.2	*Protection of cables without continuous metallic sheath* .		Used for signalling and short telephone cables only.	Not yet used.	Aluminium tape.	Copper tape steel tape.
2.224.3	*Core to sheath*	*Test voltage, volts*	2 000	2 000 after laying.	Signalling : 2 000 V, 50 c/s Telecomm. : 350 V, 50 c/s	
		Breakdown voltage, volts	—	—	Telecomm. : > 2 000 V a.c	
2.224.4	*Core to core*	*Test voltage, volts*	1 000	Same as *224.3.*	Signalling : 2 000 V. 50 c/s Telecomm. : 350 V, 50 c/s	
		Breakdown voltage, volts	—	—	Signalling : Impulse Test 0.5 ...... 2/35 ...... 50 μ sec., 40 kV/ Telecomm. : > 1 500 V A.	

(Continued).

...therlands ...ailways	*New Zealand Railways*	*Norwegian State Railways*	*South African Railways*	*Swedish State Railways*	*U.S.S.R.*	*Victorian Government Railways*
...ling : ...; ...C. ...one : ...d; ...minium; ...'.C. + copper ...e and tape.	Lead.	Lead, in future aluminium.	Lead alloy; trunk cables : aluminium.	Lead.	Lead.	Lead.
...ling : ...s + 1 tape; ...e. ...one : ...apes; ...) none.	Armoured.	Steel tape.	2-4 steel tapes; P.V.C. outer sheath.	2 steel tapes.	Steel tapes, high permeability required.	Steel wires for mechanical protection.
...ling : ...men + paper ...ute; ...C. ... : a^1) bitu- ...-paper + jute ...'.C. + bitumen ...V.	—	—	P.V.C. cover over lead sheath.	—	a.c.: polyvinyl; d.c.: cathodic protection.	Electrical drainage if required.
...224.1, cables ...	Polythen cable : copper screen, 2 steel tapes, P.V.C. covering.	Not used.	Not used.	Used for local circuits, sometimes with steel wires for mechanical protection.	Not used.	Aluminium tape between conductors and sheath proposed.
: 2 000, 50 c/s ...mm. : ...00, 50 c/s	500 50 c/s	2 000	Generally 1 000 for trunk cable 2 000	2 000	Long dist. : 1 800 Local : 500	Metal sheath 300 Plastic sheath 500
—	2 000, 50 c/s	—	—	Approx. 3 000	—	—
: 2 000, 50 c/s	500, 50 c/s	300	For trunk cable 500	1 000	Long dist. : 1 000 Local : 500	As *224.3*
—	1 000, 50 c/s	—	—	Approx. 1 500	—	—

telecommunication circuits and the replies to the majority of the relevant questions are given in Table 8.

The replies to question 2.221 show a distinct preference for buried cables, especially in the case of A.C. traction. This is reinforced by the reply to question 2.222. There do not seem to be significant differences in the position of other types of cables in relation to the rails, recorded in the reply to question 2.223.

The replies to question 2.224.1 may perhaps be summarised as follows :

As regards core insulation, paper insulation is normal for telecommunication circuits and dry core cable is implied unless impregnated paper is mentioned in the table. Lead or lead alloys sheaths are still normal but several railways refer to the use of aluminium sheaths for the future. As regards armouring, steel tapes are normal for railways using A.C. traction, generally with two tapes, although South African Railways even with D.C. traction use four steel tapes. The U.S.S.R. reply notes the importance of high permeability for the tapes.

Various protective coverings are used for protection against corrosion. The absence of details of the protection in the case of the Indian, New Zealand, Norwegian and Swedish Railways records the absence of full particulars in the reply rather than the absence of any form of protection. The British Railways' cables also come into this category. The reference to the electrical drainage in the case of the Victorian Government Railways implies the use of the equivalent of cathodic protection in this case.

Although it is only specifically mentioned in the case of the British Railways' reply, it should be mentioned that the use of cables without continuous metallic sheath is unusual except for local circuits, with the exception of the Japanese Railways in the case of A.C. traction.

The replies to the questions about cable test voltages — 2.224.3 and 2.224.4 — are generally consistent with one another, but attention may be drawn to the low test voltage applied to telecommunication cables by the Japanese Railways.

The reply to question 2.224.5 asking if the lead sheath cable is broken at intervals and, if so, whether capacitors or filters are used to maintain the screening effect of the sheath as regards magnetic induction, has not been included in the tables. Eight of the Administrations do not partition the sheath but make it continuous, the sheath might be insulated to avoid corrosion. Where D.C. railways are concerned, there might seem to be advantages in partitioning the sheath to minimise the possibilities of corrosion although at the expense of protection against induced voltage which requires continuity of the sheath. Only in New Zealand where the sheath is broken after 13 km and in Victoria, is it the practice to break the sheath. In the latter case, it is stated that gaps are not bridged.

Diverse replies have been received to the question 2.224.6 asking if the lead sheath of cables is earthed in order to obtain a screening effect as regards the electrical influence on the conductors. It might have been anticipated that there would be significant differences between the practice of railways using A.C. and D.C. traction but this is not clearly expressed by the answers. Of railways using D.C. traction, Netherlands and Victoria do not earth the sheath at all, although the Netherlands states that some old cables still operate satisfactorily continuously earthed. In South Africa the cables are earthed every 900 m. In New Zealand they are earthed by connection to the frames of exchanges and in India it is stated that the cables are earthed but it is not stated precisely where. In Japan sheaths are earthed every 15 km, on the D.C. section of the U.S.S.R. at least every 10 km and on British Railways cables are earthed at one point only and are definitely insulated in the neighbourhood of earthed metallic structures such as bridges, signal rodding, etc.

Of the railways using A.C. traction, in

Norway the cables are not generally earthed and in Sweden they are normally well earthed due to leakage because they are buried, and this may well be the case in Norway also. British Railways propose to earth every 900 m.

The replies to question 2.224.7 concerning the screening factor of cable sheaths at fundamental frequency show, as might be expected from the differing sheath arrangements described in Table 8, a wide diversity of values. This diversity is to be expected as the choice of a suitable method of screening is one of the major methods of compensating against interference effects with which this report is concerned.

It may be recalled that the screening factor is the ratio of the e.m.f. actually induced in the cable to that which would have been induced if there had not been any sheath or armouring. It varies, according to the frequency and the saturation of the iron if steel armouring is used.

British Railways adopt the screening factor appropriate to the actual requirements and visualise values as low as 0.1 at 50 c.p.s. India give a value of 0.088 at 50 c.p.s. for telecommunication cables with aluminium sheath when the longitudinal e.m.f. is between 80 and 200 V per km. Their lead sheathed signalling cables give a value of less than 0.4: this construction is used provided the longitudinal e.m.f. does not exceed 35 V per km. Japan uses cables with a screening factor of 0.4 to 0.6, the choice of design depending upon the magnitude of the catenary current. Netherlands Railways give a screening factor for their p.v.c. telephone cables as 0.96 at 50 cycles falling to 0.5 at 300 cycles, so that they get a good screening against harmonic currents circulating through their D.C. system.

South Africa quotes screening factors of 0.7 for cable sheaths, of 0.5 for two tracks and of 0.8 for two earth wires. Norway gives a table of screening factors ranging from 0.98 to 0.81 for cables of different sizes varying from 14 pairs to 74 pairs. Because of the heavy compensation of the traction system the resulting induced voltage varies from 3 to 10 V per km. The best values are quoted by Sweden for protection against induction by faulty three-phase high voltage lines, using a cable with lead sheath, aluminium wires inside the sheath and iron tape armouring. They give a screening factor of 0.018 at 50 c.p.s. for a longitudinal e.m.f. of 400 V per km and 0.04 at 16 $^{2}/_{3}$ c.p.s. at 170 V per km. Where special protection of this nature is not necessary, screening factors varying from 0.27 to 0.2 at 16 $^{2}/_{3}$ c.p.s. are normal with 140/160 V per km.

The devices under consideration in the next series of questions, of which the principal features of the replies are tabulated in Table 9, concern the extent to which telecommunication circuits are divided into sections so as to limit the value of the longitudinal voltage induced in the conductors of the cable and other questions arising out of the use of this kind of technique.

The replies notice that the use of isolating transformers at the terminals of trunk cables and their entry into repeater stations is normal practice, independent of questions arising from the electrification of the railway. They are used to form phantom circuits, for matching and separating unbalanced equipment from balanced circuits. It could be expected that additional isolating transformers would be necessary to guard against high values of induced longitudinal voltage, in the case of railways electrified on the A.C. system unless special compensation such as booster transformers is used. India proposes to use sectionalising transformers in signalling cables when the induced voltage is more than 120 V during normal operation, but with a maximum length per section of 3 km. In telecommunication cables they propose a maximum length per section of 25 km and to sectionalise the cable if the induced voltage would exceed 300 V under short circuit conditions.

Japanese Railways also propose to use

TABLE 9. —

Railway Administration : Question			*British Railways*	*Indian State Railways*	*Japanese National Railways*	*Netherlan[ds] Railways*
2.231.3 *Maximum value of longitudinal induced voltage considered ? (volts)*			C.C.I.T.T. limits (430; 60). With isolating transformers 60 % of test voltage.	Signall. 240 Telecomm. 300	300	Not releva[nt] with D.C.
2.234.1	*Excess current protection used for*	*Over-head lines*	Fuses, heat coils, protectors.	Fuses, heat coils, protectors.	Coarse lightning arrester, fuse, vacuum arrester and heat coil between open wire or cable and equipment; some without heat coil between open wire or cable, and cable.	None.
		Cables	Fuses and heat coils.	Fuses.		None.
2.234.2	*Rating of fuses*	*Current in amps*	3	1.5 and 3	3 amp. fuse acts at 4.5 ± 0.5. 0.35 amp. heat coil acts at 0.5 ± 0.05. Protection by fuse against transient induction by heat coil against overload.	—
		Reason for this selection	Post Office practice.	Corresponding to maximum working current.		—
2.234.3	*Lightning arresters (protectors)*	*Striking voltage, volts*	500	500 to 750	265 ± 35, rated at 7 amps	500 V prote[ctors] used for ove[r-head] lines on not[elec-]trified railwa[ys]
		Reason for this selection	—	To give adequate protection.	Often used with standard fuse.	
2.234.5 *Use of devices against acoustic shocks ?*			Yes, copper oxide rectifiers.	Not used.	Not used.	Not use[d] until no[w]

devices.

Zealand ways	*Norwegian State Railways*	*South African Railways*	*Swedish State Railways*	*U.S.S.R.*	*Victorian Government Railways*
relevant D.C.	800	It is not anticipated, that 430 V will be exceeded.	430	Open wires 1 000 to 1 500. Cables 200 to 250.	Between 1 000 and 2 000 V to be expected.
otectors, protec- standard st Office used on ne cir-	No current protection used.	Fuses, heat coils, protectors, conforming to Br. Post Office practice.	Different arrangements, often fuse, protector, heat coil.	Cartridge fuses and heat coils, both with delayed action.	Fuses and protectors at apparatus end of lead in cables.
	No current protection used.		Fuses are often omitted.		Protectors at junction of open wires and cables.
	Not used.	3	Fuses 3 to 5. Heat coil 0.25.	0.15 to 1.0	1.5 to 3
t Office. d.	Not used.	Recommended by suppliers of equipment.	—	—	Readily available, sufficiently sensitive. Have never blown.
00	155-160	350	1 000 V : carbon protectors, 350 V : gas discharge tubes. Gas discharge tubes to reduce induced voltages in open wire lines and some cables.	350 ± 40 against atm. discharges. 280 ± 30 against induced voltages.	Gas : 350 to 750 Carbon : 1 000
–	Used only in one case due to atmospheric induction.	—		Selected to secure normal operation.	Availability. Gas protectors reduce induced voltage to safe values.
used.	Experimentally used; double rectifier type.	Refers to a monograph on protection.	Yes, rectifier type, in mannual exchanges and soon in telephone sets. Protection against h.v. lines.	Yes, rectifier type, copper oxide or selenium.	Yes, selenium rectifier type.

sectionalising transformers when the longitudinal voltage would be too high. They limit the length of a section to 15 to 20 km, and the number of sections to five, but if the total length is more than 50 km, repeaters are used.

Norway sectionalises every 80 km and has circuits as long as 600 km. In the U.S.S.R. isolating transformers are used experimentally in carrier frequency circuits which existed before the line was electrified; the maximum length of these circuits depends on the anticipated longitudinal induced voltage in relation to the relevant C.C.I.T.T. limits.

British Railways also insert transformers in certain carrier cables at distances of approximately 50 km.

The replies to question 2.231.3 as to the induced longitudinal voltage expected under the most unfavourable conditions, summarised in Table 9, depart in some cases considerably from C.C.I.T.T. recommendation both in an upward and a downward direction.

It is of interest that in no case have test voltages been modified when sectionalising transformers are used.

The replies given to the question 2.231.4 asking for the maximum potential which might occur between two adjacent conductors under these conditions are consistent with the replies given to question 2.231.3.

The use of sectionalising transformers makes it impossible permanently to check the insulation of intermediate sections from the terminal stations; no general solution has been found to the question posed regarding this, 2.33.1, but the problem is under study in India and in Japan. In Norway, individual sections are tested once a month. British Railways test spare conductors and consider the appearance of noise in service lines is a good check, whilst the U.S.S.R. base their control upon a continuously applied air pressure.

Question 2.233.2 asks how signalling and supervisory control are affected when telecommunication lines are sectioned by transformers.

The use of A.C. in the audio or carrier frequency range is the solution to this problem adopted in Norway and by British Railways. When D.C. transmission of signals is necessary, as in the case of U.S.S.R., sectionalising of the telecommunication lines is impossible and the need for it is avoided by increase of separation for open wire lines in the U.S.S.R. or by the use of cables by the Victorian Government Railways in place of open wire lines.

The use of booster transformers by Norway, Sweden and British Railways reduces interferences sufficiently to avoid the necessity of sectionalising whilst in Japan filtered drainage coils are quoted in the answer to question 2.233.3 as a solution; the arrangement is shown on Table 12.

The information on overcurrent and overvoltage protection is compiled in Table 9 (2.234). There is in practice no difference between circuits with sectionalising transformers and directly connected circuits (2.234.4). India mentions the use of special filters for D.C. circuits in telecommunication cables. The general arrangement of protective devices is that used for more than 60 years; coarse fuse, overvoltage protector, heat coil, leaving out parts which do not seem to be necessary, according to the length of the circuit and whether cables or open wire lines are used.

The question (2.235) concerning the use of other special arrangements against electric and magnetic induction, is answered in the negative by six out of ten Administrations. Japan refers again to the filtered drainage coil (Table 12). Netherlands Railways refer to the use of transformers to separate, in the case of long extensions, a balanced circuit from an unbalanced exchange, and to the insertion of multiple filters (300, 600, 900, 1 200 and 1 500 cycles) in some telephone circuits to eliminate harmonic noise due to D.C. trac-

tion. Victoria state that filters, used in some control lines, gave a noticeable improvement. In New Zealand sheaths of the cables which actually enter the substations are isolated from those of the main cables as a protection against rise of potential in the case of an earth fault.

CHAPTER III.

This chapter deals with the arrangement of the signalling and telecommunication circuits, with particular reference to the equipment. (The arrangement of the open wire and cable lines has already been described in Chapter II.) It is mainly concerned with the arrangement of circuits along electrified railways. It concludes with a reference to the effects observed, as summarised in Table 13, although the questions to which this relates occur earlier in the questionnaire.

Particulars of the systems of track circuiting used are given in Table 10 *a*) for D.C. traction and Table 10 *b*) for A.C. traction. It was realised that as far as track circuits are concerned, it would be necessary to take into account both the effects due to magnetic induction and those produced by traction currents returning through the rails. The first named effect would, in theory, have to be taken into account in the case of very long track circuits due to the coupling between the circuit in one track and the loops formed by the catenary and earth and by the rail and earth of adjacent tracks, because of the asymmetry which exists between these circuits.

Very little information has been published on this subject. One of the objects of the questionnaire is to confirm whether the effects that are theoretically possible are of importance in practice considering the screening effect produced by the lines of rails of adjacent tracks. The more important effect is thought to be that due to traction currents circulating in the lines used for track circuits which might be of the following kinds :

a) Effects which might cause unwanted dropping of the track relay or prevent re-excitation of the track relay after previous occupation of the track due to saturation of the iron cores of track transformers, impedance bonds, etc.;

b) Effects which may be experienced when the track circuit is occupied, which might prevent the proper functioning of the track relays.

The importance of these effects would clearly differ according to whether single rail track circuits, in which one line of track is used for the traction return current, or double rail track circuits with impedance bonds permitting the use of both rails, is adopted.

For lines with D.C. electrification, Table 10 *a*) shows that the normal practice is to use 50 cycles A.C. track circuits. Single-rail track circuits are used up to a length varying from 400 to 800 m. Track circuits fed by direct current are only used in the exceptional case of the third and fourth rail system mentioned by British Railways, which, from this point of view, allows the running rails to be treated as on a non-electrified railway. The other exception is that quoted by the Victorian Government Railways as being used on rare occasions when A.C. supply is not available inverters are stated as being used as standbys.

When the normal supply frequency (generally 50 cycles) is used, special precautions against harmonics are not generally necessary but several cases of special arrangements are mentioned in Table 10 *a*) in reply to question 3.311.42. The next question asked whether any special measures were adopted in case the rectified current contains a component at normal supply frequency, due to one anode of a rectifier operating alone becoming inactive.

The only precaution mentioned other than those given in Table 10 *a*) in the reply to question 3.311.42 is that the U.S.S.R. employs protection by coded signals for track circuits, or, in yards,

TABLE 10 *a.* — **Systems of signa**

Railway Administration : Question	*British Railways*	*Indian State Railways*	*Japanese Nationa Railways*
3.311.1 Maximum length of single-rail track circuits in metres	460. As 75% of rails required for traction return, single rail circuits used only through junctions or for short lengths. Usual length 180-270.	Up to 360. Single rail A.C. track circuits are in use at points, crossings and stations.	About 500.
3.311.3 Is use of D.C. for track circuits at all permitted ? . .	A few D.C. relays are used with D.C. fourth rail system.	No	No
3.311.2 Normal feed arrangements for track circuits.	Condenser feed from 110 V, 50 c/s.	Reactance or condenser feed. Some resistance.	Double or single-closed track circuit from one end.
3.311.41 Frequency used for A.C. track circuits	50 c/s	50 c/s	50 or 60 c/s. At A D.C. points 83.3 c.s.
3.311.42 When normal supply frequency is used, precautions against harmonics of the traction current	Occasional difficulties overcome by desensitising the A.C. track relay.	12-phase rectifiers have filters for 600 and 1 200 c/s.	None.
3.311.44 Types of relays used . . .	Two element induction vane relays.	Double element induction vane type A.C. relays. Some D.C. 4 Ω relays with rectifier.	Track relays A.C. re fier or two element's duction type.

s for lines with D.C. traction.

Netherlands Railways	*New Zealand Railways*	*South African Railways*	*U.S.S.R.*	*Victorian Government Railways*
to 700. Total actual resistance must not more than 1.15 es that of two rails parallel.	Up to 400.	Up to 800.	800 for single-rail track circuit.	180
No.	No.	No.	No.	Used on rare occasions with inverter; only double rail circuits.
50 c/s	Reactance and condenser feed with two rail circuits; inductance feed with single rail.	Condenser feed.	Feed with A.C. 50 c/s, from special 3-phase 6.6 or 10 kV line along railway.	6 V A.C.
50 c/s	50 c/s	50 c/s, change under consideration.	50 c/s	25 and 50 c/s.
ble rail sections : d circuit, 2-phase y. ge rail sections : ncing impedance, se relay.	None. Signal supply line is loaded with capacitors.	Traction supply is tripped when D.C. contains 50 c/s ripple.	Filters at relay end, tuned to 50 c/s, they suppress other frequencies.	No special precautions other than restriction of single rail to 180 m and use of double rail whenever possible.
tor relays, vane re-, both induction with two elements.	Single and double coil indication (induction?) relays, polyphase relays, rectifier relays.	Two element vane induction relays.	Old : two element sector induction relays. New coded : pulsed track relay with biased core and rectifier, or transistorised relay. Stations with single-rail circuits have NR relays with rectifier.	Two element vane and polyphase relays.

TABLE 10 *a*. — **Systems of signa**

Railway Administration : Question	*British Railways*	*Indian State Railways*	*Japanese Nationa Railways*
3.311.45 Arrangement of track circuits	Condenser feeds circuit. Impedance bonds are tuned, or auto bonds are used.	Closed track circuits.	Single and double both with standard quency (50 or 60 A.C. and adjustable r tors. With double t circuits, auto imped bonds are used.
3.311.46 Methods to prevent saturation effects due to traction current on single rail track circuits	Capacitor in single rail track circuit rated for full traction voltage, blocks any D.C.	Shielding impedance across relay, or transformer.	Track resistor, 4 Ω 3 amps at both limits possible D.C.
3.311.47 Maximum unbalance at which impedance bonds work normally	Traction currents through halves normally to be within 15 % of each other.	20 %	20 % of rating of one coil of impedance b
3.311.48 Protective devices for track circuits	1 500 V, 10 amps fuses with or without discharge gap, in separate boxes.	Fuses only.	None.

a high signal level, whilst the Indian State Railways say that normal parallel connection of two rectifiers generally gives the necessary protection, although sometimes an unbalance relay is used to trip out a defective rectifier.

If the replies in Table 10 *a*) to questions 3.311.2, 3.311.45 and 3.311.46 are

for lines with D.C. traction *(continued).*

Netherlands Railways	*New Zealand Railways*	*South African Railways*	*U.S.S.R.*	*Victorian Government Railways*
e rail : variable or feed. le rail : tuning ensor feed.	Single rail, double rail with different types of bonds.	Single rail : 20 μF variable capacitors; 1 : 1 transformer. Feed and local coil of relay of same phase. Double rail : auto-band type, variable capacitors.	Outside stations, two rail track circuits, fed continuously or coded. In stations, single rail track circuits, continuously feeding two rail circuits sometimes.	Shielding impedance units used.
ncing impedance or and reactor in .	Shielding units provided.	Happens not often; shielding unit fitted, when required.	Relay transformer with air gap is used, as well as resistors.	Shielding impedance shunts track coil of vane relay, or forms part of balancing bridge for polyphase relay.
dance bonds have nuous rating of amps, 750 for each coil. Track cir- vell operates with mps in one side, the other side unbalance).	Bonds designed for 200 amps unbalance. If this occurs, track circuit is faulty; fault will be corrected.	20% allowed.	12%	Up to 200 amps unbalance.
in all circuits.	Protectors and fuses have been used; fuses gave rise to more trouble than protectors. Today : no more protectors, necessity of fuses investigated.	Fuses at both ends, protectors at relay end.	Fuses, protectors, and special devices already mentioned.	All tracks fused.

read together, a general similarity in the methods of feeding and arranging the track circuits will be found. There do not seem to be significant differences in the maximum unbalance with which impedance bonds will work, or in the protective devices for the track circuits, except to note with interest the absence

Railway Administration : Question			*British Railways*	*Indian State Railways*
3.312.1	*Single rail track circuits*	*Maximum length in metres*	460 for single rail D.C. circuit.	Up to 750 for single rail circuit.
		Feed arrangements	Fed from rectifier.	—
3.312.2	*Protective devices used for D.C. track circuits*		Fuses at both ends. Relay immunised against wrong side failure, up to 1 000 V, by magnetic shunt and series choke if necessary. Choke in series with rectifier. Sometimes automatic disconnection.	Series chokes, resistor sl surge arresters.
3.312.31	*Considerations regarding choice of frequency for A.C. track circuits*	*General consider-ation*	Frequencies in usual power range preferred; used only, where D.C. interference is anticipated.	83 1/3 proposed.
3.312.32		*Fundamental only, or full range considered ?*	Distinct from fundamental and harmonics, thus between fundamental and second harmonic.	Considering mainly f mental and third.
3.312.33		*Transients considered ?*	Such low frequencies probably not affected by transients.	No.
3.312.4		*Harmonics of rectifier locomotives considered ?*	All harmonics.	Only third harmonic sidered.
3.312.51	*Value of track circuit frequency in relation to traction frequency . . . .*		Between fundamental and second, where A.C. used.	Betwwen fundamental third.
3.312.52	*Particular methods adopted to avoid disturbance by traction currents . . . .*		Complication of modulating any supply to be avoided. Single phase A.C. generated for each individual track circuit also used. Discriminator rectifier, not immunised D.C. relay.	No other measures are posed.

for lines with A.C. traction.

Japanese National Railways	*Norwegian State Railways*	*Swedish State Railways*	*U.S.S.R.*
for single rail, D.C. and c/s.	Ca. 700. 50 and 100 c/s.	On lines and in small yards, D.C. track circuits, relays at both ends, fed with continuous D.C. Up to 1 000 m exceptionally 2 500 m. In big yards, and vicinity, A.C. track circuits, up to 1 000 m, fed by rotary converters, 2-phase relays.	900, used in stations and with A.C. only.
sed circuit fed from one , with rectifier or track sformer.	—		—
tector, series reactor and stor at both ends.	Only short single rail circuits, up to 60 m.	Series choke shunt resistance. For > 1 000 m, choke at battery as well. Fuses and lightning arresters used.	Single rail D.C. not used.
quencies around 1 000 c/s most suitable, consider- amplitude of harmonics, attenuation of rails.	In stations 50 c/s 2-phase relays; 100 c/s 2-phase relays on lines with automatic block.	Large harmonics must be avoided; thus 50 c/s not used in modern installations. 100 c/s sometimes used, because easely provided. Modern installations use 75 c/s.	Traction frequency, transmission of power with 50 c/s, considered.
harmonics considered.	No difficulties with third harmonic (50) or sixth harmonic (100).	Fundamental and harmonics considered. E.g. voltage drop along rail for 400 A. C/s : 16 2/3, 50, 83 1/3, 100, 116 2/3. V/km: 75, 9.0, 4.0, 0.5, 1.0.	Fundamental and harmonics.
No.	No.	No.	No.
—	Not used.	—	Mainly 150 c/s considered.
h harmonics, e.g. twelfth sixteenth for two posi- track circuits; odd har- ics, e.g. fifteenth and teenth, for three posi- track circuits.	Above the fundamental frequency. 100 c/s is actually about 98, because produced by converters with asynchronous 50 c/s motors, thus no coincidence with sixth harmonic.	75 c/s between fourth and fifth harmonic.	75 c/s
d-pass filter suppresses t parasitic frequencies; frequency selector am- er; voltage limiter, rec- r.	No other measures.	Two-phase system seems to give sufficient protection.	Pulse currents used.

Railway Administration : Question				*British Railways*	*Indian State Railways*
3.312.53	*Limiting values*	*Normal operation*	*danger*	100 V (50 for A.C. vane relays)	600 amps in contact wi
			distur- bance		
		Fault conditions	*danger*	Higher values permitted, but only for a few cycles.	3 000 amps
			distur- bance		
3.312.6	*Protection against overvoltages, if impedance bonds are used, in the case of broken rail*			No step up winding used. Extra winding will be isolated and resonated.	Surge arresters in freq intervals.
3.312.7	*Are resonance devices used ? . . . .*			With h.v. A.C. resonance normally not necessary. Winding can have higher impedance values.	Not with 83 1/3 c/s t circuits.
3.312.8	*Relays*		*Type*	*a)* A.C. : Double element vane induction relays. *b)* Standard 9 ohm D.C. relays. *c)* Immunised 9 ohm D.C. relays.	A.C. relays B.S. D.C. relays B.S. 1
			Characteristic	*a)* Control winding 1 V, local winding 110 V. *b)* Not immunised, fed through discriminator and rectifier.	—
3.312.91	*Effects of traction current on track circuits*		*Normal working conditions*	Not seriously affected by normal traction currents. Common rail, cross bonding reduce broken rail risk. Insulations subjected to-intermittent-higher traction voltages. Improvements may prove necessary.	No experiences.
3.312.92			*A broken rail in track circuit*		

Japanese National Railways	*Norwegian State Railways*	*Swedish State Railways*	*U.S.S.R.*
o 300 V depending on ment.	Not taken into consideration.	Less than 100 V/km	—
			< 40 V single rail track circuit. < 5 V double rail track circuit.
		Less than 1 500 V.	—
			—
age limiter with audio ency, lightning arrester 83.3 c/s.	Impedance bonds are saturated at a current far below that inducing dangerous voltages.	Used only for short sections. No special measures.	Saturation of reactors.
nance condenser coned to secondary.	Used at some older block installations.	No.	No.
nall, plug-in type D.C. ack relay. element, 2 positions track lay for 83.3. rack relay for audio equency.	Two-phase relays.	*a)* A.C. : Drum-and disc type relays. *b)* D.C. : Non polarized- and polarized type relays.	Pulsed track relays in all cases used. Biased relay with rectifier.
—	—	*a)* Control winding 1.4 - 14 V; local winding 110 V. *b)* Control winding 47 - 105 mA minimum operation current.	—
No effects.	Outside stations possibility of interference if sections are 600 m or more without impedance bonds.	No trouble with normal currents; short circuits are quickly disconnected. The D.C. component in an unsymmetrical short circuit dies out so quickly as not to be significant.	No trouble. Spark gaps between masts and rails mentioned.
	Faulty occupancy indicated.	Up to 1 500 V may appear. Fuses would protect, but then circuit is out of operation. Without fuses, equipment destroyed in a very few cases.	1 200 m section, 76 amps in half winding, 24.5 V in main winding.

of fuses, or other devices, on the Japanese National Railways. This seems to be the present opinion of the New Zealand Railways and suggests that the devices used by all the other Railways may not be necessary with these cabled circuits.

It is clear from the replies noted above and scheduled in Table 10 *a*) that no difficulties are experienced with track circuits with D.C. traction.

Corresponding particulars to similar questions on railways equipped with A.C. traction are given in Table 10 *b*). The answers given by the Indian State Railways, and to some extent those given by British Railways, refer to the arrangements proposed in distinction to those of which service experience has been gained. There is no significant difference in the maximum length of single rail track circuits which in this case vary from 460 to 900 m. There are, however, very marked differences in the method of feeding track circuits, in the replies to question 3.312.31 listed in Table 10 *b*).

The majority of the lines use a frequency other than that of the power supply but within the power frequency range, but the Japanese National Railways consider that frequencies around 1 000 cycles per second are most suitable, taking into account the relationship between the magnitude of the disturbing voltage and the attenuation of the track circuit.

The reply of the U.S.S.R. does not, of course, imply that they use traction frequency but only that they distribute to their relay cabins at power frequency, as is seen by the reply to question 3.312.51.

British Railways normally use D.C. track circuits but A.C. track circuits are used when D.C. interference is likely to be encountered as, for example, where equipment must work on a railway operating on D.C. but to be converted to A.C.

To appreciate the methods adopted to avoid disturbance by traction currents, it is necessary to read the replies to questions 3.312.51 and 3.312.52 together.

Generally, it seems to be agreed that the choice of a suitable frequency, coupled in the Swedish case with a two-phase system, gives sufficient protection, but the Japanese National Railways use band-pass filters to suppress parasitic frequencies and the U.S.S.R. use pulse currents in association with their 75 cycles track circuiting system. The British Railways use of D.C. track circuits differs therefore from the general practice.

The absence of a reply from the Japanese National Railways to question 3.312.4 asking which harmonics arising from the use of rectifier type locomotives have been considered, should be read in conjunction with their answer to 3.312.32, thereby bringing this reply into line with British Railways, in contrast to the opinion of the Indian State Railways and the U.S.S.R. that the third harmonic is the one mainly to be considered.

It is difficult to compare the answers given to question 3.312.53 seeking a distinction between the limiting values under normal and fault conditions on the traction side from the aspects of danger and disturbance to the regular functioning of the signalling system.

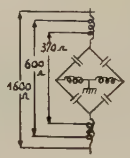
From the answers given to questions 3.312.91 and 3.312.92, it would appear that the measures taken have avoided interference under normal working conditions, but that some difficulties remain on certain railways with a broken rail in the track circuit.

Question 3.313 asking what arrangements have been made in stations with two or more types of electrification has only been answered by the three Railways concerned in this problem, the Japanese National Railways and British Railways who use 83.3 cycles and U.S.S.R. 75 cycles. In all cases the reply concerns the case where there is D.C. traction and traction at A.C. standard frequency. British Railways' reply concerns a railway which is to be converted from 1 500 V D.C. to 25 kV A.C., whilst remaining in public service and they add that the 83.3 cycles current is

TABLE 11. — **Other types of signalling circuits.**

Railway Administration : Question	*British Railways*	*Indian State Railways*	*Netherlands Railways*	*Swedish State Railways*	*U.S.S.R.*
3.321 Kinds of signalling circuits other than track circuits	On A.C. traction, every lineside signalling circuit is provided with a separate return, and both, the line and return are switched. Circuits over about 1.2 km are sectionalised and repeat relays are provided.	Manual block. Electrical control of mechanical signals from two or more cabins. Colour light signals.	In one case overlay track circuit used.	Cable pairs for control.	All other types of signalling circuits make use of cables; they are part of the main cable with a special sheath.
3.324 Limiting values — Normal operation — Danger	60 V	120 V	—	No need for special limiting values. covered by limits for telecommunication circuits.	250 V
3.324 Limiting values — Normal operation — Disturbance	Due to close spacing, no difficulties.	—	—		—
3.324 Limiting values — Fault conditions — Danger	430 V	240 V	—		500 V
3.324 Limiting values — Fault conditions — Disturbance	Due to close spacing, no difficulties.	—	—		—

TABLE 12. —

Railway Administration : *Question*	*British Railways*	*Indian State Railways*	*Japanese National Railways*	*Netherlan Railway*
3.331.1 Description of telecommunication circuits used for telephony	Circuits use loop calling, loop ringing and loop battery dialling. One leg of each extension is earthed, when not in use.	*a*) Long distance: circuits are transformer terminated, manually operated. 17 c/s signalling. *b*) Control circuits : omnibus; selectors actuated by 3.5 c/s coded D.C., 100 to 300V. At ends bridged by balancing resistance (*?*). *c*) Auto telephone, on cable and open wire circuits. Line relays, uniselector, 17 c/s calling. *d*) Short distance: local telephones, 17 c/s calling. With A.C. traction, carrier frequency to be provided. All circuits balanced.	All telephone circuits (previously using earth return) are changed to metallic (double wire) circuits. For magneto operation in party lines, special device used; dialling in automatic party lines under study.	Automat telephony through di with A.C. i ses. Party employ ma or pole cha Some centra tery system used.
3.331.2 Description of telecommunication circuits used for telegraphy	Audio frequency teleprinter.	Single or double current telegraphy at 50 bauds; phantoms of long distance circuits used, with earth return, for teleprinter and morse. With A.C. traction, audio frequency used for long distance.	Filtered drainage coil used. 	Direct line tween telepr Connections means of a type switch Audio frec telegraphy. telegraphy.

ommunications.

w Zealand Railways	*Norwegian State Railways*	*South African Railways*	*Swedish State Railways*	*U.S.S.R.*	*Victorian Government Railways*
Carrier fre- cy circuits audio fre- cy ringing. ong distance: bus " rural natic ". In rified areas, sulated com- return con- or is used for ng instead of 1. Exchange tele- e circuits con- to British practice.	All circuits use double line side circuits or phantoms. Magneto ringing or dialling.	Main trunk circuits provided by carrier channels. For traffic control selector circuits. Signalling from control centre by keys; no back ringing, as centre listens in permanence. Station to station lines (omnibus type) use code ringing with magneto generator.	*a*) Long distance: carrier operation on symmetrical pairs, calling with 500 c/s, or audio on loaded quads, 15-50 c/s calling. *b*) Automatic dialling impulses transmitted by means of 1 500 c/s, up to 75 km often with 60 c/s. *c*) Party lines use D.C. impulses. *d*) Local subscribers lines are separated by capacitors.	Carrier frequency and audio frequency with standard commercial equipment. Automatic or manual systems with selective or mutual selective calling. Call signals: D.C. or A.C. at 3.5 to 50 and 300 to 2 400 c/s. In stations, automatic equipment and manual switchboards used.	Trunk circuits : physical lines (up to 240 km) ringing with 17 c/s; or carrier channels, ringing with modulated 1 000 c/s. Station service lines, up to 80 km, use 17 c/s ringing. Harmonic lines use ringing frequencies of 20 to 66 c/s at 100 V. Selector lines use up to 400 V, 3.5 c/s for calling. Automatic exchange services, up to 16 km in cable. Manual local battery and common battery switchboards.
ectrified areas audio or high uency carrier nels.	Some teleprinters are installed, otherwise no telegraphs left.	In electrified areas, separate pairs are used for telegraphy. Teleprinter network uses audio frequency channels.	Audio frequency channels used; for short lines double phantoms.	Carrier frequency and audio frequency channels, as well as single wire with earth return (not with A.C. traction). Baudot, teleprinter, morse used.	Usually phantoms with earth return, but not in electrified areas. Carrier channels used for teleprinter.

TABLE 12. — S

Railway Administration : Question	*British Railways*	*Indian State Railways*	*Japanese National Railways*	*Netherland Railways*
3.333 Sensitivity coefficients . . .	C.C.I.T.T. limits. Screening of cables avoids difficulties.	No data available.	Open wire < 0.003, cables < 0.0003, automatic telephony switchboards < 0.01, other equipment < 0.0001.	No data avail
3.334 Limiting values — Normal operation — danger	C.C.I.T.T. limits.	With A.C. traction C.C.I.T.T. limits.	60 V	Telecommunic circuits and ec ment are affe only in case physical da (fire, explosic
3.334 Limiting values — Normal operation — disturbance			1 mV telephone cables, 2.5 mV teleph. open wire. 30 % of signal for telegraphy.	
3.334 Limiting values — Fault condition — danger			300 V	
3.334 Limiting values — Fault condition — disturbance			—	

generated in each relay room concerned and that distribution is by a screened cable over a strictly limited length. The U.S.S.R. mention that at both ends of the track circuits 2-Ω resistances are connected as a protection against parasitic direct currents.

The next series of questions concerned types of signal circuits other than those used in track circuiting, to which the limited replies received are summarised in Table 11. The replies concern diverse circuits in which it is most unusual to use earth connections. Little trouble with interference has been experienced.

Table 12 gives particulars of the replies

ommunications *(continued)*.

Zealand Railways	*Norwegian State Railways*	*South African Railways*	*Swedish State Railways*	*U.S.S.R.*	*Victorian Government Railways*
—	Approx. 0.0005	—	Open wire, copper < 0.004 Open wire, iron < 0.01 Cable < 0.0035	No data available.	Transformers are used only for matching, formation of phantoms and in carrier installations.
—		—		open wire { wooden poles 60 V, concrete poles 36 V local cables 36 V main cables 36/450 V.	—
—	C.C.I.T.T. limits.	—	C.C.I.T.T. limits.	See text.	—
—		Maximum current setting of track circuit breaker 3 500 amps.		open wire { wooden poles 1000 V, concrete poles 75 V cables: 60% of test voltage.	—
—		—		—	—

received as regards systems of telecommunication and does not draw a distinction between those railways which are electrified on the A.C. and on the D.C. system. It is evident that practically all available types of circuits for telephony and telegraphy are used by one or more of the Administrations.

The long distance circuits very often use carrier channels and are thus nearly immune to inductive effects. The risk of disturbance arises more for medium and short distance circuits. The types that can be used for this purpose may perhaps be determined by the need to use selective

TABLE 13. — **Observed**

Railway Administration : *Question*		*British Railways*	*Indian State Railways*	*Japanese National Railways*	*Netherlanc Railways*
3.111 *Disturbance by*	*Fundamental frequency*	A.C. traction : to date no disturbance.	—	Because of protective means provided, no effects experienced.	— (D.C. onl
	Harmonics	A.C. traction : to date no disturbance. D.C. traction : no disturbance.	Noise observed with 3 000 V D.C. was due to faulty rectifier transformer. Smoothing equipment successfully used.		Noise only perienced, terminal e ment is ou balance. Hi value on cabl cuit alone 0.7 Balance of e ment is esse
3.112 *Danger to persons or equipment*		No damages or accidents.	No danger to persons or equipment experienced.		No accidents served.
3.12 *Special precautions during work on telecommunication circuits*		With A.C. traction : temporary bond provided before continuity of sheath is broken.	No accidents. None.	None, except overcurrent and overvoltage protection (Table 9).	None.
3.21 3.22 *Difficulties due to corrosion on*	*Railway cables*	No undue difficulties experienced.	Some corrosion of telecommunication cables, both railway and public observed.	Corrosion observed with D.C., but not with A.C. traction.	Corrosion ol ed on railwa public cable well as on ga water pipes. blem seriou long pipes. thodic prote used.
3.23	*Public telecommunication cables*				

ction and corrosion.

w Zealand Railways	*Norwegian State Railways*	*South African Railways*	*Swedish State Railways*	*U.S.S.R.*	*Victorian Government Railways*
:ulties arise fact that only ing rails form nuous earth he country, thus stray nts from pu- supply. On other hand, on D.C. en- public net- and operates reducing hes. Reme- coded track ls, use of dif- t frequencies.	Disturbances are only perceptible in case of faults in telecommunication circuits.	No disturbance; D.C. traction only.	Bad rail joints give occasionally rise to false ringing in subscriber's sets in the public telephone network.	With A.C. traction, risk of disturbance must be considered.	Disturbances observed by fundamental and low harmonics from power lines, by frequencies up to 30 000 c/s from rectifiers.
		Occasional noise observed, when smoothing filters for rectifiers are faulty.	Otherwise no disturbance.	Disturbances by rectifier harmonics observed in audio telephony and high frequency carrier. Also in block circuits (100 and 200 c/s), when rectifiers do not work normally.	
bility of g side failure uipment.	No danger registered.	No danger.	No danger.	No damages or accidents experienced. Risk of danger has to be considered with A.C. traction.	Risk of danger for linesmen. Protection of equipment is sufficient.
accidents. ed, when in progress.	Sheaths are temporarily bonded before any joint is opened.	—	No special directions in force.	Safety rules have been established. Telecomm. lines to be handled as cautiously as high voltage lines.	No accidents. Rules for "joint use" of poles applied.
osion of da- d track cir- and telecom- cation cables ved.	No corrosion observed.	—	No corrosion observed.	Corrosion observed on cables for all purposes, if not properly protected. Protection against stray currents by drainage or cathodic protection, against soil corrosion by insulation.	Some corrosion of cross bonds and cable sheaths.
—		—			—

or code calling which is a particular feature of railway telephony.

The abandonment of earth return for telecommunication circuits on railways using A.C. traction is significant among the replies to question 3.331.1 and the reference to the balancing of all circuits in the Indian Railways' reply is important and is confirmed by the Netherlands Railways' reply to question 3.111 (see Table 13). No doubt this view, though not expressed explicitly, is shared by other Administrations, as it has been known to be necessary for many years and has been stipulated in the C.C.I.T.T. Directives for many years. In addition to the replies given in the table, Swedish State Railways give some data concerning the public telephone system in that country, of which no particulars are given in the other replies.

The Swedish particulars are as follows :

" Long distance connections are multichannel carrier systems (co-axial or symmetrical pairs); calling and dialling by audio frequency signals. Medium distances (15 to 300 km) are served by audio frequency circuits on loaded cable quads or copper open wire. Ringing with 25 c/s, if circuits are manually operated. With automatic operation, signalling by means of pulses (condenser discharges) fed inductively into the line. Junction circuits up to 25 km use loaded cable pairs or iron open wires. Ringing again with 25 c/s with manual operation; with automatic operation, D.C. dialling system is in use leaving the line balanced during the conversation and sufficiently balanced when not in use. "

The answer to the question if metallic connections to earth are used for any railway telephone circuits is generally in the negative. They are avoided by the Netherlands and Norwegian Railways and probably by the New Zealand Railways. In India, only morse circuits use earth return, in Sweden only local subscribers' line and junction circuits, the railway party lines having a special battery supply without an earth connection. The Japanese Railways' answer makes it clear that automatic telephone switchboards involve the use of earth circuits which is probably also true for other Administrations, but the lines themselves will be earth-free. In U.S.S.R. the earth is used for single wire telegraph circuits associated with D.C. but not A.C. electrifications, and for local telephones.

The answers to the question 3.333 asking the sensitivity coefficient of each significant part of these circuits have been tabulated in Table 12 and where replies have been given they are in general similar to the answers given to question 2.2.13.

The limiting values permitted in normal operation and under fault conditions, question 3.334, are in general those suggested by the C.C.I.T.T., but the following set of limits which have been standardised by the U.S.S.R. for fundamental frequency induced voltages are of interest :

Operating conditions of railways. Type of communication line		*Normal or emergency supply*	*Short-circuit*
Open wire lines	On wooden poles	60 volts	1 000 volts
	On reinforced concrete poles	36 volts	75 volts
Cables	Local circuits	36 volts	60 % of the test voltage
	Main circuits	36/450 volts	60 % of the test voltage

For main circuits in cables, the 36 V limit applies without special protection measures, the 450 V limit, when special protection measures have been taken, e.g. installation of isolating transformers. With regard to disturbances during normal operation — disturbance during short-circuits is not considered — and in the case of D.C. traction, the translation of the answers says that the " psophometric noise voltage on load terminals of a two-wire circuits should not be over 1.55 mV, divided by the square root of N where N is the number of repeater sections of carrier frequency telephone lines for which exposure to the railway is possible ". This translation might be erroneous, as such a limit applies usually to individual sections only. If this is assumed, the total psophometric voltage for N sections would be 1.55 mV, because the contributions of individual sections to the total noise are independent and are summed up as an r.m.s. value, N sections giving $\sqrt{N}$ times as much as one section. The U.S.S.R. reply continues: " With A.C. traction, the limit is 1 mV per repeater section of audio frequency telephony. For telegraph circuits, with D.C. traction, the limit of the parasitic current introduced by railway stray currents is 1 mA for high speed telegraph system, and 2.5 mA for morse telegraphy. With A.C. traction and two-wire telegraph circuits, no disturbance is to be expected if the noise in telephone circuits — on the same line — is below the limit given above. "

Effects on signalling and telecommunication side.

Some of the effects likely to be experienced have already been mentioned at the beginning of this chapter. The questionnaire asked, question 3.1, for particulars of important effects to be classified under the following headings:

3.111. Disturbance by fundamental frequency or by harmonics;

3.112. Danger to persons or equipment;

3.12. What special directions are in force concerning precautions to be taken when working on telecommunication circuits with regard to danger from the voltages produced by electro-static or electro-magnetic effects?

Please give particulars of your experience of accidents to persons and equipment so caused and state whether the cause was electro-static or electro-magnetic in origin,

and question 3.2 asked for particulars of any difficulties due to corrosion on any of the following services:

3.21. Railway signalling;

3.22. Railway telecommunications;

3.23. Public telecommunications;

If so, please give information as to the nature and extent of the difficulties and of the measures taken to find the causes and to obviate them.

The replies received to these questions are given in Table 13. They may be summarised to the effect that as far as D.C. traction is concerned, interference effects have generally been negligible and owing to the precautions described in the report, the same is true of A.C. traction.

So far as D.C. railways are concerned, the exception is the New Zealand Railways who seem to have difficulty in getting good earth connections in a soil of high resistivity and have experienced conductive coupling between running rails and domestic power supplies with multiple earthed neutrals. The remedy has been to change their signalling equipment to 60 cycles so that it is immune from interference from the public supply system at 50 cycles. The reply from the Victorian Government Railways is not very explicit as regards the means taken to overcome the difficulties they mention, but it would appear that the necessary steps have been taken to immunise the equipment.

In the case of the railways using A.C.

traction, it would appear that there is some risk of disturbance when either the traction or the telecommunication circuits are faulty, but notwithstanding the summary in Table 13, the replies indicate that the measures taken to avoid these are generally successful. All of the Administrations confirm that the precautions taken avoid danger to persons or equipment and most of the replies to question 3.12 indicate special measures that are necessary to ensure the safety of staff working on the signalling and telecommunication equipment.

As regards corrosion, most of the railways indicate some difficulty with D.C. traction and all of the Railways using A.C. traction report freedom from corrosion. The Netherlands Railways and the U.S.S.R. report the use of cathodic protection for reducing corrosion effects.

It is unfortunate that not more of the Administrations have given particulars relating to public telecommunication systems. Reference has already been made to the reply of the Swedish Railways. The reply of British Railways stresses the importance of correlating any measures taken to avoid interference with railway signalling and telecommunication circuits with those which will be satisfactory so far as the public telecommunication services are concerned. The extent to which public telephone services in Great Britain utilise imperfectly balanced circuits goes some way to explaining the adoption by British Railways of the booster and return conductor system for compensation for most of their lines using A.C. traction in spite of relatively low soil resistivity. The other Administrations with which the report is concerned, using A.C. traction (Japan, Norway and Sweden) who adopt this technique have an additional reason for doing so in their high soil resistivity.

It is perhaps permissible to summarise the contents of Table 13 by the observation that it would appear that proper and thorough execution of the methods selected has perhaps been even more important than the selection of a particular method to avoid interference. The variety of methods shown in the replies to the questionnaire develops, of course, from local considerations and often from historical development. It is satisfactory, but not surprising, that Table 13 shows that these various methods have served their purpose so as to permit the proper operation of the railways.

It was not thought proper to include in the questionnaire questions relating to the economy of various methods that could be adopted, and indeed, the wide variations in the types of railway are such as to preclude any satisfactory economic comparison of one with another.

[656 .225 (73)]

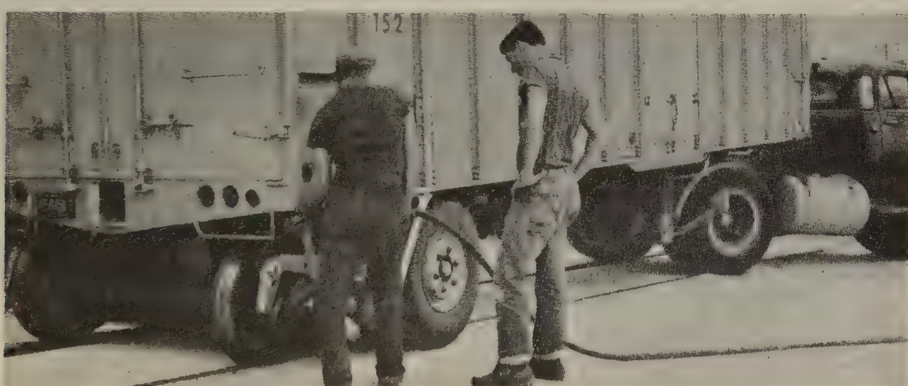
C & O tests improved Railvans.

These hybrid rail-highway vehicles are speeding mail and express traffic on 500-mile Michigan run,

by Tom SHEDD Jr.

(*Modern Railroads*, August, 1959).

Railvans are rolling on the Chesapeake & Ohio. The unique rail-highway vehicles (Modern Railroads, June 1956 p. 94), are now in actual revenue service. Attached to the rear of passenger trains 25 and 26, they're carrying mail and express on a 500-mile, six-days-a-week round trip between Grand Rapids and Traverse City-Petoskey, Mich.



Air is used to transfer the van load from rail wheels to highway wheels.

The experimental Railvan operation began last May, when three units started running between Grand Rapids and Traverse City. Recently, four more vans were added and the service extended to Petoskey.

To date, the Railvan service has proved successful both for the railroad and its customers. « We've had some 'nut and bolt' failures, but no basic troubles », says G. J. Sennhauser of the C & O's Research Department. The Research Department, under Director of Research K. A. Browne, developed Railvan and is working to improve it.

Railvan represents still another approach toward coordinating rail and highway transportation. It's intended to utilize the most efficient aspects of both modes. Any future large-scale Railvan operation might well be performed by a « third party », which would lease the equipment to truckers and others, and perhaps carry on the transfer operations.

As highway vehicles, the single-axle Railvans, with their 27-ft, 1 500-cu-ft bodies, could operate over the streets of any U. S. town or city. They would be converted to rail operation and assembled into trains

at rail-highway transfer points. They would move between cities as rail vehicles, perhaps in solid trains of as many as 150 vans, and would bypass all rail yards en route.

This scheme would use the railroad for the « wholesale » part of the transportation job — the line haul; while highway tractors would perform the « retail » part of the job within metropolitan areas. In effect, the Railvan system is « piggyback without the flatcars ». Without flatcars, the dead weight, clearance and tiedown problems of conventional piggyback would disappear — along with costly and time-consuming terminal rail switching.

Of course these advantages aren't obtained cost-free. Because they must be designed for the conditions of rail service, and because of their dual running gears, Railvans are heavier and more expensive than conventional highway trailers of the same capacity. However, the greater cost of the vans is said to be offset by the elimination of flatcars and the fact that no ramps or other structures are needed at terminals.

C & O began work on the Railvan project in 1952. The first prototype vans were built in 1955 (they're now in England, where British Railways is studying the system). The new vans, built by Visioneering, Inc., of Cleveland, incorporate improved versions of the same tubular underframe, plug-and-socket couplers, modified landing gears and dual road-rail rear wheels with torsion springing. Redesign of the body has cut total weight by 900 lb. It is now under 10 000 lb, of which about 4 000 is due to the requirements of dual service.

The side sheets, of .072 in. aluminum, now have integral side posts. They're made in standard modules. Rear door posts are of improved tubular steel design. Underframe members are of Yoloy EHS — 35 to 40 % stronger than mild steel and only a little more costly. « Racking » tests have verified the extreme rigidity of this body.

Railvan « Train », after arrival at Grand Rapids, is broken up and prepared for highway transit by transfer unit — in a matter of minutes.

The Grand Rapids-Traverse City operation (see photos) doesn't fully test the economic possibilities of the Railvan. But it does provide a good proving ground where C & O can keep tabs on the new vans while they roll up a high daily mileage.

At Grand Rapids a special « transfer unit », made by Dwight Austin of Kent, Ohio, handles Railvans in the station area. It can uncouple a van, convert it from steel wheels to rubber tires, park it, ready for highway transport, in just over a minute.

A siding, with gravel-surfaced adjacent area, serves as the transfer center at Traverse City. No transfer unit is used here. Instead, a standard highway tractor, equipped with dump AAR coupler, plus a portable air jack are employed.

The three Traverse City vans contain, respectively, post-office mail, express, and star route mail (the star route van is worked at the transfer siding, much like a setout baggage car).

On a typical day recently, the three vans were separated, transferred to their highway wheels, and the mail van was en route to the post office within 6 min of the setout time. This mail arrived at the post office 35 to 40 min earlier than it would have with the conventional transfer from baggage car to local truck — and one handling of the mail was eliminated.

Underframe of van is low-alloy high-strength steel; center sill is seamless oil well pipe. Improvements made in design of the 27-foot, 1 500-cubic foot van have cut its weight to under 10 000 pounds.

[625 .13 (52)]

Construction of Hokuriku tunnel,

by Shoichi HARAGUCHI.

(*Japanese Railway Engineering* No. 1, July 1959.)

I. HISTORY OF PLANNING FOR HOKURIKU TUNNEL.

The Hokuriku Line constitutes a part of the coast line along the Japan Sea. It has come to have a very important bearing on the railway service of J.N.R., because it is the shortest cut to connect the Osaka-Kobe area, the industrial area, with the northern part, the natural resources area, of Japan, and because the chemical industry has been rapidly developing along the line especially since the end of the war. In the daily average service per route kilometer, the freight traffic on the Hokuriku Line between Tsuruga and Imajo amounts to 16 354 tons, though no more than 10 911 passengers are carried, whereas, in the total of J.N.R., the traffic volume comprises 6 549 tons of freight and 13 979 passengers daily.

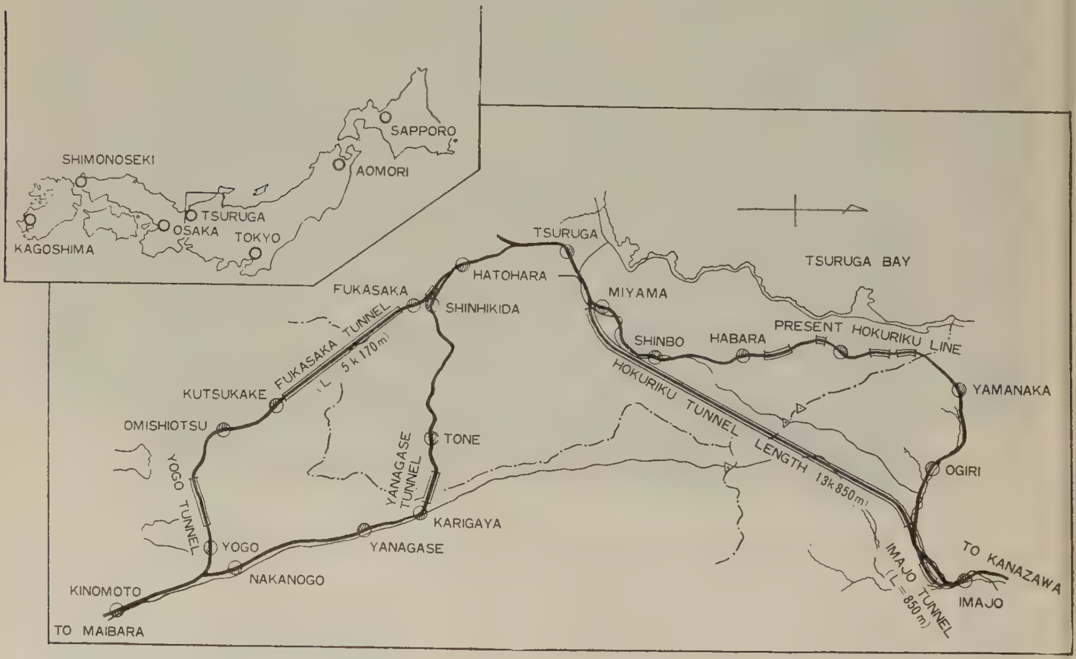


Fig. 1.

The Hokuriku Line is single for the most part, and the shortage in the traffic capacity considerably affects the transportation as a whole. As remedial measures, a greater number of cars are hauled

by double engines, and detour services through the Tohoku, Joetsu and Tokaido Lines are made. But the demand for traffic is much greater. To solve this state of affairs, J.N.R. took up the project of double-tracking the Hokuriku Line which is planned to be completed before 1962. The additional track is designed to be laid roughly along the existing track. However, for the Tsuruga-Imajo section where the grade is 2.5 % continuously, a 13 850 m long double track tunnel, to be called Hokuriku Tunnel, is being constructed away from the existing track, as indicated in figure 1, to improve the grade to 1.2 %.

The existing track will be improved as shown in the following table by constructing this tunnel. This section will also be electrified by 20 kV A.C., the same system as the already electrified Maibara-Tsuruga section.

The new tunnel, Hokuriku Tunnel, is to be the longest in Japan, 4 200 m longer than Shimizu Tunnel (9 700 m), Joetsu Line. It will be the 5th longest in the world as shown in the following table.

Item	Existing line	New line	Remarks
Track length (km)	26.0	19.2	
Steepest grade (°/₀₀)	25	12	
Minimum radius of curvature (m)	362	600	
Highest formation level (m)	274	166	Altitude above sea level
Way stations	3	0	
Way signal stations	3	0	
Total length of tunnels (m)	4 170	14 700	
Longest tunnel (m)	1 200	13 850	
Operation time (min.)	40	20	
Others	Single track	Double track	

No.	Name	Country	Length (km)	Remarks
1	Simplon	Switzerland-Italy	19.8	Single track, two separate tunnels
2	Apennin	Italy	18.6	Double track
3	St. Gothard	Switzerland-Italy	15.0	»
4	Loetschberg	Switzerland-Italy	14.5	»
5	Hokuriku	Japan	13.85	»
6	Mt. Cenis	France-Italy	12.8	»
7	Cascade	U.S.A.	12.5	Single track
8	Arlberg	Austria	10.0	Double track
9	Moffat	U.S.A.	9.9	Single track
10	Shimizu	Japan	9.7	»

II. GEOLOGICAL FEATURES OF HOKURIKU TUNNEL.

Over the whole length of the tunnel paleozoic rock (clayslate and graywacke alternating) is distributed except for a granite section about 1 000 m long in the middle part. The rock is fairly solid, but, cracks which are characteristic of paleozoic structure, are expected to be numerous. There is a fault which runs roughly north and south along the higway and the tun-

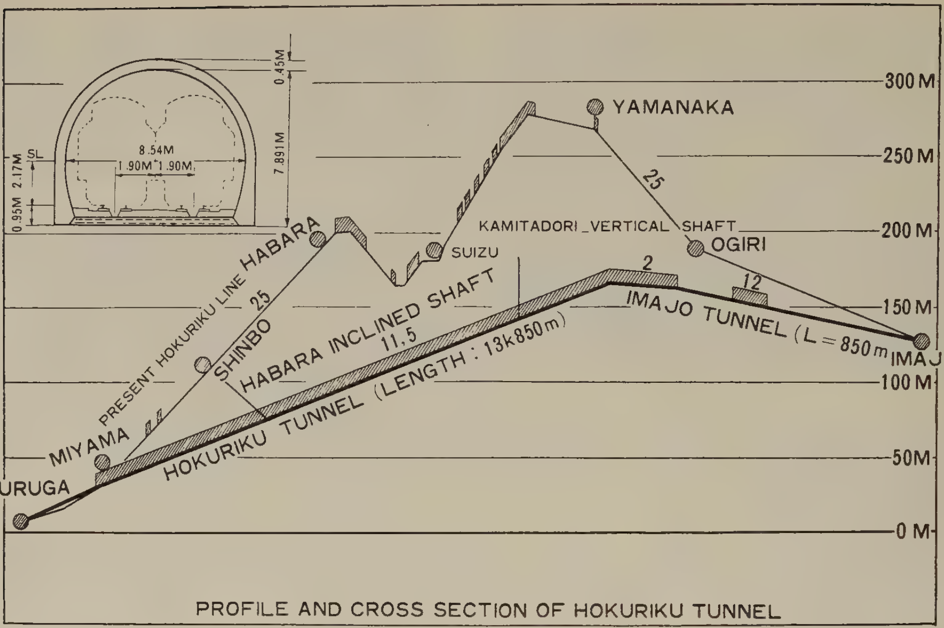


Fig. 2.

nel crosses the fault near Itadori. Because of the effect of the said fault, there seem to be at several places small faults and crushed zones, though not on a big scale.

III. THE DESIGN AND THE METHOD OF CONSTRUCTION.

Design.

The maximum uphill grade is 12/1 000, and the grade in the tunnel is 11.5/1 000. As indicated in figure 2, the grade is one way for the most part, because of the difference in the altitudes between Tsuruga and Imajo.

The cross section of the tunnel is as shown in figure 2. The track structure is expected to have a concrete bed with a view to saving maintenance expenses in future. The volume of work of Hokuriku Tunnel is as tubulated below.

Work item	Cross-sectional area (m^2)	Length (m)	Amount (approx.) (m^3)
Excavation	64.5	13 850	900 000
Concrete lining	10.3	13 850	143 000
Concrete bed.	2.1	13 850	30 000
Road bed concrete	3.1	13 850	43 000

Work period.

The service over the Hokuriku Line has seen a deadlock. Makeshift operation will be possible for 4 more years, by increasing the cars to be coupled to a train i.e. raising the nominal hauling capacity of a train from 700 tons to 1 000 tons, improving the facilities of existing stations and by making special train schedules, so that the frequency of service will increase from the 70 trains of 1957 to 93 trains for 1962. However, the situation is considered to be hopeless, allowing for no remedial measures. With 1962 set as the deadline the present work is being carried on under considerable pressure of time.

The progress of work is scheduled as follows.

Work item	Average progress	Target of completion
Excavation	160 m/month	Aug. 1960
Concrete lining	200 m/month	Oct. 1960
Concrete bed and road bed concrete . . .	1 000 m/month	Jul. 1961

Work method.

To complete a 13 850 m long tunnel within 4 years means reducing to half or less the commonly accepted average speed of tunneling for a double track. To this end, an inclined shaft (about 460 m long) and a vertical shaft (about 230 m deep) must be laid in the middle course of the tunnel so as to increase facings, and a full-section excavation method using the most up-to-date, powerful equipment must be employed.

The plan of execution is as follows.

1) Rock drilling.

Full-section excavation will be made by rock drill jambo of 18-19 booms. The progress by one blast is 2.5 to 3 m.

2) Blasting and ventilation.

As blasting is done electrically with D.S. detonators, the ventilation capacity is designed at 500 m³ or more. Hence two 200 HP turboblowers, and 76 cm for the diameter of the ventilation pipe.

3) Mucking.

Conway electric shovels, 100-type and KR-68 type will be used. With 2 units laid parallel, a capacity of 200 m^3/h or more is expected. A 10-ton battery locomotive hauls 6 steel made much trucks of a capacity of 6 m^3. The gauge is 36″.

4) Timbering.

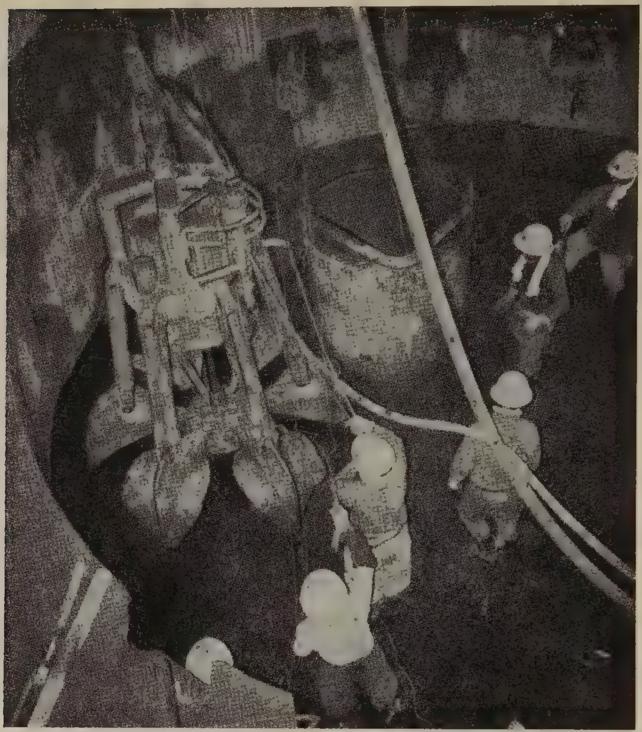
Props, made of used 50 kg and 30 kg rails, will be spaced at 1.2-1.5 m. This spacing may be shortened depending on the geological conditions.

5) Concrete lining.

To increase the speed of work and improve the quality of concrete, concrete pumps will be employed and the frame will be made of steel and be movable.

6) Measures against water.

The most threatening problem in the excavation of the tunnel is that ground water is encountered unexpectedly. Therefore, drain pumps of a nominal capacity of 5 m^3/min and maximum capacity of 10 m^3/min are provided. A 500 HP Diesel generator is also provided for use in the event of the power going off.



Excavation of a vertical shaft.

A gigantic jambo with 18 to 19 booms drilling
for a double track at one time.

After blasting, two Conway electric shovels are kept busy with mucking.

A freight train puffing up on the Hokuriku Line.

Work forces.

The project has been undertaken by Gifu Regional Construction Office, and directly responsible within this organization is Tsuruga Branch Office holding a total of 55 J.N.R. regular employees who are assigned to 4 construction offices in the field, except for those working at the Branch Office (see hereafter).

Tsuruga Branch Office	16 workers
Taniguchi Field Construction Office	13 workers
Habara Field Construction Office .	7 workers
Itadori Field Construction Office .	6 workers
Imajo Field Construction Office . .	13 workers
Total . . .	55 workers

The section between Tsuruga and Imajo is divided into 5 work sections, each assigned to a contractor as follows.

Work section	Length in charge (m)	Contractor	Number of labourers per day at peak time
1st work section	4 940	Nishimatsu-Kensetsu	500
2nd work section	2 900	Kumagaya-Gumi	500
3rd work section	2 000	Taisei-Kensetsu	500
4th work section	2 700	Sato-Kogyo	500

Total amount of labour required : About 1 100 000 man-days.

Supply of electric power.

Power required for the execution of work at Tsuruga side and for the work to proceed from the inclined pit at Habara will be supplied from Tsuruga Substation of Hokuriku Denryoku K.K. (Hokuriku Electric Power Co.) at 3 kV and 6 kV, respectively. For the work to proceed from the shaft at Itadori, power will be received from a substation installed by J.N.R. near Magoya at 70 kV and supplied after being stepped down to 6 kV. For the work on the Imajo side (power will be stepped down to 3 kV at Magoya Substation.

[625 .143 .5]

Powerful spring washers for railway tracks.

In the superstructure of the permanent way, to fix the rails to the sleepers bolt type apparatus are preferred. Thanks to these, the different components are solidly assembled and the rail is pressed against the sleeper with considerable pressure. The latter condition is essential to prevent rail creep and to give the track a certain rigidity, which is of particular importance for the stability of the track when long welded rails are used.

When the track is laid, the bolt is tightened up, i.e. put under traction, and it then has to maintain this tightness. In general, for this pourpose, a spring washer is used, which is inserted under the head of the bolt or under the nut. The elastic force thereof is then exactly equal to the tightness of the bolt, which we will designate by Z. The task of the spring washer is to absorb the deformations and displacements which occur in the rail fastening device and compensate these in such a way that the bolt loses very little of its tightness ΔZ (fig. 1).

Let us recall the fact that deformation in the assembly occur under the effect of the moving loads and may be of two kinds : either elastic, which only occur for a short instant as each axle passes, or permanent and gradually increasing, as for example the plastic compression of a sole plate or of the bearing surface itself, or again the gradual wear of any component. The spring washer must be able to meet both these two kinds of deformation, and it can only function satisfactorily if its elastic characteristic i.e. the relation between the force applied and the relative displacement of its bearing points is suitable for the deformations expected. This elastic characteristic is affected by the material and dimensions of the section of the washer but still more by its shape.

The loss of thigtness ΔZ must be kept within strict limits, both for the part ΔZ_{bl} (permanent deformation) in order to prevent rail creep and assure the rigidity of the body of the track (fig. 2), and the part ΔZ_{el} (elastic deformation) in view of the resistance to repeated oscillations of both washer and bolt (fig. 3); it must be pointed out that ΔZ_{el} represents a release of very short duration but repeated millions of times.

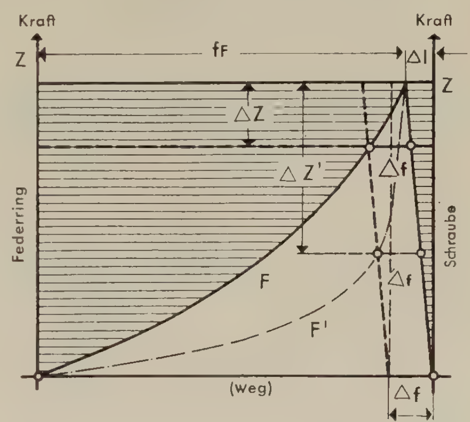


Fig. 1. — Determination of the loss in tightness ΔZ from the force-deformation diagrams for a spring washer and the body of a bolt.

f_F = compression of the spring washer for Z (in tons).

Δl = elongation of the body of the bolt for Z (in tons).

Δf = vertical deformation in the assembly.

with a powerful spring washer

F = characteristic of the spring ΔZ = loss of tightness.

with an unsuitable type of spring washer

F' = characteristic of spring ΔZ = loss of tightness.

N. B. — Federring = spring washer. — Schraube = bolt. — Kraft = force. — Weg = displacement.

High tension bolts — which are those of which it is generally question on railway track — require very powerful spring washers to keep them tight. The latter are characterised by the fact that they do not have the shape of a spring with a regular slope but include in their coils cambers of a well

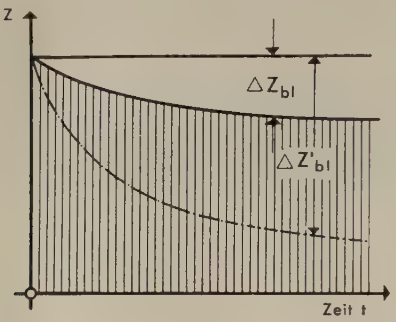


Fig. 2. — Loss in tightness ΔZ_{bl} owing to a permanent deformation Δf_{bl} in the assembly ($\Delta Z'_{bl}$ shows what happens with an unsuitable type of spring washer).

N. B. — Zeit = time.

defined size and arrangement. If these spring washers are compressed slowly and progressively, as figure 4 shows, there first of all occurs a very gentle elastic effect due to the predominance of the torsion stress. But as soon as the cambers come into contact, under the effect of a given force of compression $\overline{Z}$, the action of the spring becomes more marked and a definitely greater resistance is felt, as it is then above all a question of the flattening of the cambers in the coils due to flexion. Thanks to these cambers, the greatest deflection f_{max} is only obtained under a tightening up Z_{max} much greater than the tightening up $\overline{Z}_{max}$ that could be obtained if the washer was only acting as a torsion spring.

The tightening power of a spring washer is in reality only determined by its elastic behaviour in the field of high loads.

The German Railways (D.B.) like several other Administrations have used with good results for many years three types of powerful spring washers manufactured by the firm « Vossloh-Werke » (Werdohl, Germany) : the spring washer with one coil Fe 7, the double spring washer Fe 6 and the triple washer Fe 19 (see fig. 5 to 7).

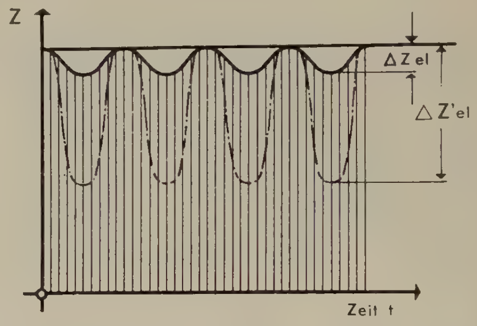


Fig. 3. — Loss of tightness ΔZ_{el} owing to elastic deformation in the assembly ($\Delta Z'_{el}$ shows what happens when an unsuitable type of spring washer is used).

The primordial consideration in the examination of these three types lies in the fact that with the increase in the number of coils it is possible to increase the size of the supplementary cambers, in other words

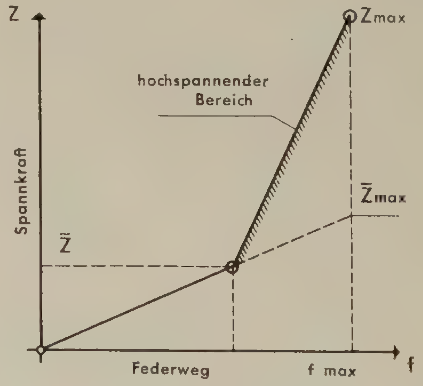
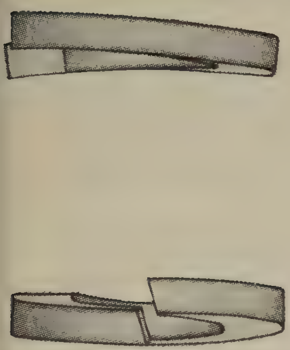
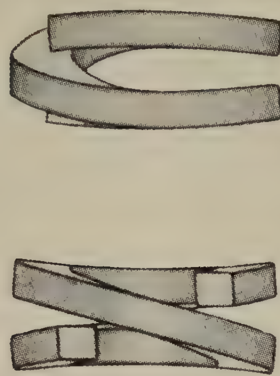


Fig. 4. — Diagrammatic representation of the diagram of the force-deformation of a powerful spring washer.

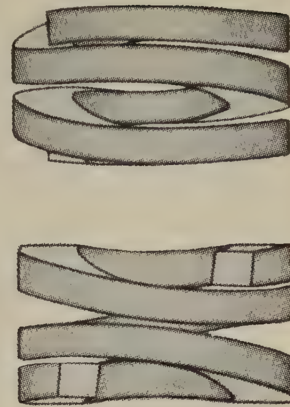
N. B. — Federweg = deflection of the spring. — Spannkraft = tightening up force. — Hochspannender Bereich = field of great tightening.



Fe 7
Fig. 5.



Fe 6
Fig. 6.



Fe 19
Fig. 7.

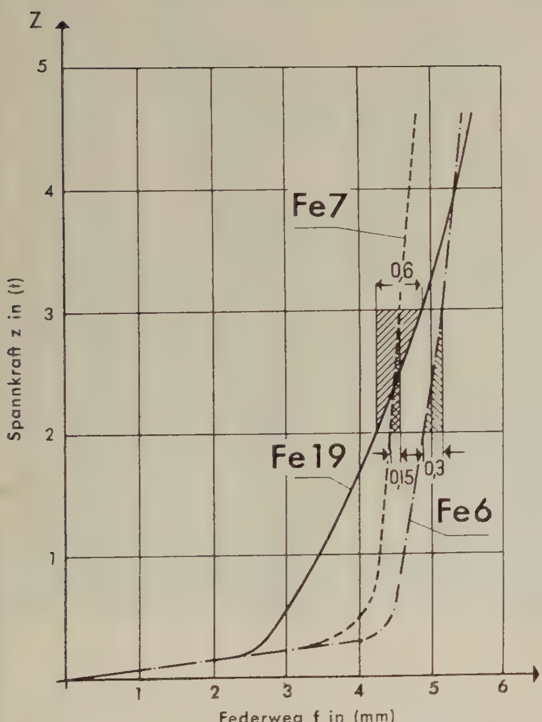


Fig. 8. — Characteristics of spring washers Fe 6, Fe 7 and Fe 19.

N. B. — Federweg f in (mm) = deflection of the spring in mm. — Spannkraft z in (t) = tightening up effort in t.

extend their distance of support, which makes the spring washer more flexible in the field of very severe tightening up and consequently more effective.

Figure 8 shows the characteristics of the three types of spring washers; it clearly shows the differences in their power. For example, if the value of Z increases from 2 to 3 t the deflection of the spring washers Fe 7, Fe 6 and Fe 19 vary respectively from 0.15, 0.30 and 0.60 mm.

The admissible vertical deformations in the assembly can vary in the same proportion (1:2:4) should a spring washer have to be replaced. The single spring washer Fe 7 would only be used if very slight deformations Δf are expected, and on the other hand the triple washer Fe 19 when relatively high values of Δf are expected; as for the double spring washer Fe 6, which is the type most frequently used to date, this is recommended for average conditions.

The bolt has the fortunate property of being easy to tighten up, which makes it possible to make good entirely any plastic deformation or wear of the parts making up the whole. But frequent tightenings up represent increased maintenance work which is often costly. It is undoubtedly much cheaper and more rational to put a very powerful tight spring washer under the

bolt and thus make it rarer to have to tighten it up, or even never.

The useful life of a spring washer is above all a question of its resistance to fatigue. This depends upon many factors : the material, the internal stresses in the superficial zones of the section, the condition of the surface, the friction conditions at the points of contact, attack by corrosion; finally it is essentially determined by the fact that a part initially subjected to a high load Z will in the long run, even under favourable conditions, only stand up to a reduced supplementary vibrating load ΔZ_{el}. Here again a powerful spring washer is advantageous. The longer the undulations in the coil, the smaller the variation of the stresses for a given variation of deflection Δf.

The behaviour of the coachscrews in the wood sleepers or in the wooden pegs of a concrete sleepers also depend on Z and ΔZ_{el}. A powerful spring washer with a low value of ΔZ is a guarantee that the coachscrew will stand up to conditions satisfactorily for a long time.

Consequently, Railway Administrations have at their disposal for all types of conditions, a strong, rationally designed spring washer, and it is for them to make a choice of the most suitable spring washer for the particular case in question.

[385. (09 .2]

OBITUARY.

Shri P.C. MUKERJEE,

Former Chairman Railway Board, Ministry of Railways, Government of India.

Former Member of the Permanent Commission of the International Railway Congress Association.

We have learnt with deep regret of the death on the 5th January last of Shri P. C. Mukerjee till recently Chairman, Railway Board, Ministry of Railways, Government of India, and Member of the Permanent Commission of our Association.

Shri P. C. Mukerjee, M. A. (Cantab), M. I. E. (India) was born on October 30, 1904, in Calcutta. He received his education at Calcutta and Clare College, Cambridge. After graduating, he joined the ex-East Indian Railway as an Assistant Engineer at the age of 21, on November 26, 1925. He subsequently held the posts of Assistant Superintendent (Staff), Employment Officer, Executive Engineer, Personnel Officer, etc.

In August 1940, his services were placed at the disposal of the then Department of Supply under the Director General, Munitions Production, Government of India. Later, he took charge as Deputy Director General, Munitions Production.

He returned to the ex-East Indian Railway in 1947 as Deputy General Manager, and was subsequently promoted as Divisional Superintendent on that Railway. He was appointed General Manager of the ex-Bengal Nagpur Railway in April 1948.

On May 1949, he took over as the first General Manager of Chittaranjan Locomotive Works. He was connected with it from its inception to the time of its completion.

During his association with the railways, Shri MUKERJEE studied in many new railway installations abroad, in U.S.A., Europe and U.K. He also paid a short visit to Japan.

During his tenure in the Board's Office he was intimately connected with the speedy execution of the various projects during the first Plan and the first half of the second Plan.

During his long years of service, momentous changes took place in the Indian Railways. He proceeded on leave preparatory to retirement on July 1, 1959, after a long and distinguished career on the Indian Railways.

Shri MUKERJEE was nominated a member of the Permanent Commission of the International Railway Congress Association in 1957.

In spite of his heavy duties, he always showed the greatest interest in the works of our Association. In particular, we may recall that he represented the Railway Board of India at the Enlarged Meeting of the Permanent Commission held in The Hague-Scheveningen in June 1956, and at the Madrid Congress of 1958, he was Vice-President of Section IV (General).

Shri P. C. MUKERJEE was always a faithful friend of our Association. He distinguished himself by his clear sighteness, logic and competence, and his affable character earned him the sympathy of all his colleagues on the Permanent Commission. He was one of the promoters of the Enlarged Meeting of the Permanent Commission held in New Delhi in December 1959.

We offer his family our sincere condolences.

The Executive Committee.

NEW BOOKS AND PUBLICATIONS.

[**385** (05]

Jahrbuch des Eisenbahnwesens. 10 Folge, 1959. *(Annual Review of railway matters. Tenth Year, 1959).* — Edited by Prof. Dr.-Eng. Th. VOGEL, *Chairman of the Central Office of the Bundesbahn at Munich.* — A bound volume (8 1/4 × 11 1/2 in.) of 232 pages, with numerous illustrations. — 1959, Darmstadt, Carl Röhrig Verlag, Holzhofallee, 33a.

For the tenth year in succession, the well known and popular work for railway technicians, the « Jahrbuch des Eisenbahnwesens » has been published.

In the editorial of this tenth volume, Dr.-Eng. SEEBOHN, Minister of Communications of the German Federal Republic, defines the position of Germany in world economics, and stressing the leading role played in this field by railway, maritime, river and air transport, he characterises the evolution which has taken place in the last ten years. He concludes by insisting upon the need for co-ordination between all the different methods of transport which should contribute to the general well being through a free exchange of ideas.

Numerous articles, drawn up by notable personalities of the railway world, hold the attention of the reader and call attention to the main points in the evolution of technique in the various fields of railway science : the change-over in traction in the Netherlands, modern designs of motor units for mountain railways, description of the standardised passenger coaches of the Swiss Federal Railways, the design of the 1 000 HP Diesel locomotive of the Deutsche Bundesbahn, the high quality permanent way of the French National Railways, a description of the centralised traffic control equipment of Frankfort-on-Main, a comparative study of rail and road transport.

A general study of the railways of Greece and proposals for their future development in a country whose relief is a particularly difficult one shows the vitality of this method of transport.

This same point is also brought out by the description of the European Railways Exhibit at the Brussels International Exhibition of 1958, as well as the report on the activities of the Deutsche Bundesbahn in 1958.

The volume ends by a review of the research work and the chief technical realisations carried out during 1958 by the various Railway Administrations, as well as statistical data on the railways of the world.

R. S.

[**385** (09 (45)]

ITALIAN STATE RAILWAYS. — **F. S. 58** — A volume (8 1/4 × 11 inches) of 100 pages with numerous maps and photographs in black and white and in colour. — 1959, published by the Documentation Department of the Italian State Railways.

The Italian State Railways have just published their report on their activities for the year 1957-1958.

Issued in a new form, copiously illustrated with coloured photographs, maps and diagrams, this report makes particularly pleasant reading.

Beginning with an analysis of the financial management of the undertaking, it gives the overall results, studies the repercussions of the general economy on railway transport, examines the movement of supplies and orders to the national industry and stresses the importance of the contribution made by the railway in increasing the national income.

The report then comments upon the main tendencies in the commercial and

economic policy of the railway and gives numerous comparative statistics for the traffic of the last five years.

The technical undertakings embarked upon during 1957-1958 are also the subject of a detailed report, in which mention is made in particular of the main electrification projects (power stations, substations, catenary) and telecommunication projects that have been carried out, the most important improvements made to the permanent way and bridges, the different types of rolling stock (electric and Diesel locomotives, coaches, wagons) put into service, the experimental work and scientific researches undertaken.

The report devotes an important chapter to the education of the staff, to automation, the organisation of the work and increasing of productivity, as well as to social matters.

It ends with a brief mention of the vast programme of renewal and improvement projected for the years to come, which bears witness to the vitality and functional importance of the Italian State Railways.

R. S.

[**385** (09 (44)]

Activité et productivité de la S.N.C.F. en 1958. *(Activity and productivity of the S.N.C.F. in 1958).* — Published by the French National Railways Company. — A pamphlet (8 1/4 × 10 1/2 in.) of 32 pages, with maps, graphs and tables.

The S.N.C.F. has just published a pamphlet giving the main results of its activities in 1958.

In his preface M. DARGEOU, General Manager of the S.N.C.F., stresses the fortunate results of the capital investment policy followed by the S.N.C.F. for more than ten years, which has enabled it to increase its transport capacity very considerably and meet the ever growing demands of the national economy, whilst also improving to a great extent its output, its costs and the quality of its services.

During 1958, the traffic underwent a slight reduction compared with the previous year (1.3 % in the case of freight and 0.9 % in the case of passenger traffic), but still remains very much greater than that of 1929, the best prewar year (28 % in the case of freight and 14 % in the case of passenger traffic).

The number of employees has been somewhat reduced and the productivity of the staff has fallen slightly in 1958, after the steep rises of 1956 and 1957.

The year 1958 was marked by an important extension in the electrification of the system (531 km), with 50 cycles 25 000 V single phase between Paris and Lille and between Dole and the Swiss frontier, and with 1 500 V D.C. south of Lyons. Moreover, the acquisition of 1 800 and 2 000 HP Diesel locomotives made it possible to extend Diesel traction for hauling heavy trains on the main lines.

These changes in traction resulted in an increase of about 3 % in the power productivity of the S.N.C.F., the total increase compared with 1938, being 150 %.

In addition to new work in connection with the electrification schemes, the fixed installations benefited from important technical progress in the field of signalling, telecommunications, and work on the permanent way and infrastructure.

As regards the working, the S.N.C.F. has done all in its power to improve the quality of the services offered (higher speeds, greater regularity and safety, introduction of car-ferry services, services for carrying private cars, the transport of lorries and semi-trailers by long distance trains), whilst adapting the tariffs for the services offered to their actual cost.

The pamphlet is completed by a series of diagrams, maps, and statistical tables showing the activities of the S.N.C.F. as a whole.

R. S.

CORRIGENDA.

ENLARGED MEETING OF THE PERMANENT COMMISSION (NEW DELHI, 1959).

REPORT ON QUESTION 2,

by J.J. Jonker, published in the *Congress Bulletin* for October 1959.

Page	Item	There is :		It must be :	
		JNR Train set A	JNR Train set B	JNR Train set A	JNR Train set B
938/10	*Power rating*				
	Continuous rating	—	—	470 HP	470 HP
	One hour rating	470 HP	470 HP	760 HP	760 HP
	Starting power	760 HP	760 HP	—	—
944/16	*Tertiary transformer windings*	No separate windings		Tertiary winding on the primary side of transformer	
954/26	*Total power of auxiliaries*		11 and 22 kW		11 kW
		JNR - Locomotive ED 46		*JNR - Locomotive ED 46*	
944/16	*Measures to reduce weight*	Radial core to save space and weight; silicon steel plates		Radial core to save space and weight; Directional (orientated) silicon steel plates	
		DB - Locomotive E 320		*DB - Locomotive E 320*	
945/17	*D.C. traction circuit control*	1 weak field position		5 weak field positions	
947/19	*Field weakening method*	Inductive shunt		Ohmic shunt	
	Efficiency	Yet to be decided		N = 99,3 %	
949/21	*Rectifier cooling*	Air cooling (output not stated)		Air cooling combined with cooling for traction motors (With separate cooling 36 m^3/min would be sufficient)	
	Protective action	Special high-speed circuit-breaker		Powerless high-speed circuit-breaker (Schnelltrennerschutz)	
	Weight H.P. ratio	0,765 kg/H.P.		0.11 kg/H.P.	
	Ripple voltage	Not yet known		30 % at 16 2/3 Herz	

Page	Item	There is : DB - *Locomotive E 320*	It must be : DB - *Locomotive E 320*
953/25	*Auxiliaries*	Motorgenerator 250 V 1-ph, A.C., 16 2/3 or 50 c/s ? V, 3-ph, 50 c/s.	—
954/26	*Auxiliaries (continued)*	1 oil pump motor for transformer	220 V/380 V (3 ph-50 c/s) for oil pump motor
957/29	*Automatic switch-over when taking vehicle into operation*	?	No automatic action — only control of proper choice of system

SPECIAL REPORT ON QUESTION 2,

by J.J. IONKER, published in the *Congress Bulletln* for November 1959.

1025/9	*Total weight (metric tons)*	84,0	82,5
	Total weight of the electrical installations including the motors	—	39
	Weight of the electrical installations excluding the motors	—	26,2
	Weight of transformer	12,0	11,4
	Total weight in kg pr H.P.	23,8	23,5
1029/13 1st. col. 41st. line	5.2.2. *Rectifier locomotive*	« The transformer of the E 41 locomotives has... »	The transformer of the ED 46 locomotives has...»
1033/17 1st. col. 32nd line	6.1. *Traction motors*	That is what the J.N.R. are doing with their multiple unit coaches as well as with their locomotives	J.N.R. always use resistance speed-control system

MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(APRIL 1960)

[016. 385 (02]

I. — BOOKS.

In French.

1960 62 (01
CRAWFORD (A.E.).
Technique des ultra-sons. Applications à basse et haute puissance. Traduit de l'anglais et adapté par Ing. J. PALMÉ.
Paris (6e), Dunod, éditeur. Un volume (14 × 22 cm) de 470 pages, avec de nombreuses figures. (Prix : 48 N.F.)

1959 691
Journée Internationale des Applications des Matières Plastiques à l'Industrie. (30 avril 1959.) Numéro de décembre 1959 de la *Revue Universelle des Mines.*
Liège, Revue Universelle des Mines, 22, rue Forgeur. Un fascicule (20.5 × 30 cm) de 40 pages, abondamment illustré. (Prix : 125 fr. belges.)

1959 624 .2
KOLOUSEK (V.).
Calcul des efforts dynamiques dans les ossatures rigides. Vibrations des poutres, des portiques et des arcs. Traduit du tchèque par V. MOZIS.
Paris, Dunod, éditeur, 92, rue Bonaparte. Un volume relié de 300 pages (16 × 25 cm) avec 80 figures.

1959 624 (06
Mémoires de l'Association Internationale des Ponts et Charpentes. Volume 18. Année 1958.
Zürich, Librairie Leemann. Un volume (17 × 24 cm) de 296 pages avec 181 figures.

1959 621 .392
NÈGRE (J.).
Le soudage électrique par résistance. *3e édition.*
Paris (8e), Publications de la Soudure Autogène, 39, rue d'Amsterdam. Un volume (16 × 24 cm) de 432 pages avec 194 figures. (Prix : 1 750 fr.fr.)

In German.

1959 625 .15
DROSZIO (L.).
Spitzenverschlüsse und Grossteile der Weichen und Kreuzungen. 1. Auflage.
Leipzig, Fachbuchverlag. 118 Seiten (14.7 × 21.5 cm) mit 175 Bildern und 2 Einschlagtafeln. (Preis : kart., DM 5.80.)

1959 621 .335 (43)
Handbuch der elektrischen Triebfahrzeuge der Deutschen Bundesbahn. Verfasser : E. BITTER, G. HENNING, K. WEISS und K. SANDER.
Frankfurt (Main), Verlag « Voraus », Westendstrasse 50. 432 Seiten DIN A 5, 432 Seiten mit über 200 Zeichnungen, Bildern und Schaltplänen. (Preis : Plastikeinband, DM 14.—.)

1959 62 (01
REICHERTER (G.).
Handbuch der Härteprüfungen nach Brinell, Rockwell, Vickers. 2. Auflage.
Berlin-Göttingen-Heidelberg, Springer-Verlag. 216 Seiten 8° mit 106 Abbildungen, 56 Prüfbeispielen und 50 Tabellen. (Preis : kart., DM 12.50.)

1959 656
Schiene und Strasse 1959. Herausgegeben von Prof. Dr. Dr. BRANDT.
Dortmund, Verkehrs- und Wirtschafts-Verlag GmbH. 191 Textseiten. (Preis : DM 17.50.)

In English.

1960 385 (09
ALLEN (P.) and WHITEHOUSE (P.B.).
Narrow gauge railways of Europe.
Hampton Court, Surrey : Ian Allan Limited, Craven House. (Price : 35 s.)

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(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels, (See « Bibliographical Decimal Classification as applied to Railway Science », by L. WEISSENBRUCH, in the number for November 1897, of the *Bulletin of the International Railway Congress* p. 1509).

1959 313 : 659

Annual Bulletin of Transport Statistics for Europe. — 1958.

One brochure of 105 pages, illustrated.

Published by the Economic Commission for Europe, United Nations, Geneva.

1959 385 (061 .4 (73)

Bulletin - American Railway Engineering Association. Vol. 61, No. 553, November.

Reports of Committees to be presented to the 1960 Convention of the Association.

A brochure of 162 pages, illustrated.

Published by the American Railway Engineering Association, 39, East Van Buren Street, Chicago.

1960 385 (09 (42)

CARTER (E.).

An Historical Geography of the Railways of the British Isles.

One volume (10 × 6 3/4 in.) of 637 pages.

London : Cassell & Co. Ltd., 35, Red Lion Square, W.C. 1. (Price : 63 s.)

1960 385 (09 (42)

HAMILTON ELLIS (C.).

British Railways History, 1877-1947.

One volume (9 1/2 × 6 1/4 in.) of 416 pp. + 25 pp. plates.

London : George Allen & Unwin Ltd., Ruskin House, 40, Museum Street, W.C. 1. (Price : 35 s.)

1959 385 .08 (59

Malayan Railway Administration Annual Report for the year 1958.

One brochure of 130 pages, illustrated.

Printed for Malayan Railway Administration by the Caxton Press (1957) Limited, Kuala Lumpur. (No price stated.)

1960 385 .1

Nigerian Railway Corporation. Annual Report for t year ended 31st March 1959.

Published by the Nigerian Railway Corporatio Ebute Metta, Nigeria. (No price stated).

In Italian.

1959 621 .431 .

COSTANTINI (A.).

Automotrici ferroviarie con motori a combustio interna.

Roma, edita dal Collegio Ingegneri Ferroviari Italia Piazza Croce Rossa.

Volume I, mille pagine con 1 100 illustrazioni.

Volume II, 15 tavole (schemi elettrici e pneumat relativi alle diversi unità di automotrici descritte n testo).

In Netherlands.

1959 62 (

Ten Bosch Viertalig Technisch Woordenboek.

Deventer, N.V. Uitgevers-Maatschappij AE.E. Kluw 10, Polstraat.

Een band (14 × 20 cm) van 700 bladzijden. (Prij 27.50 gulden.)

[**016.** 385 (05]

II. — PERIODICALS.

In French.

Acier-Stahl-Steel. (Bruxelles.)

1960 624

Acier-Stahl-Steel, janvier, p. 33.

de MIRANDA (F.). — Aspects fondamentaux de la **construction mixte acier-béton.** (4 000 mots & fig.)

Annales de l'Institut Technique du Bâtiment et des Travaux Publics. (Paris.)

1959 691

Annales de l'Institut techn. du Bâtiment et des Trav. Publics, décembre, p. 1313.

CHEFDEVILLE (J.). — **Béton de blocage et mortiers activés.** (6 000 mots, tableaux & fig.)

1960 721

Annales de l'Institut techn. du Bâtiment et des Tr Publics, janvier, 29.

BUISSON (M.), AHU (J.) et HABIB (P.). — **frottement négatif.** (Sols et fondations). (8 000 mo tableaux & fig.)

1960 6

Annales de l'Institut techn. du Bâtiment et des Tr Publics, janvier, p. 133.

ALBIGES et FREDERIKSEN. — **Calcul à la rupt des dalles** par la théorie de Johansen. (5 000 mo tableaux & fig.)

Bulletin de l'Association Suisse des Electriciens. (Zürich.)

1959 621

Bull. de l'Ass. Suisse des Electriciens, 19 décemb p. 1271.

GAUSSENS (P.). — **Réglage des fluctuations a atoires de tension** dans les réseaux électriques. (2 800 m & fig.)

1960 **621** .31
Bull. de l'Ass. Suisse des Electriciens, 16 janvier, p. 2.
DASSETTO (G.). — **Barres de connexion** en aluminium. (5 400 mots & fig.)

1960 **621** .31
Bull. de l'Ass. Suisse des Electriciens, 16 janvier, p. 2.
JEAN-RICHARD (Ch.). — La **protection des barres omnibus** à 16 et à 50 kV. (650 mots & fig.)

Bulletin de Documentation S.C.E.T.A. (Paris.)

1960 **388** (44)
Bulletin de Documentation S.C.E.T.A., janvier, p. 8.
LANGEVIN. — Les **transports de voyageurs dans Paris et la Région parisienne.** Recherche d'une organisation rationnelle. (2 000 mots & fig.)

Bulletin Sécheron. (Genève.)

1959 **621** .335 (494)
Bulletin Sécheron, nº 28 F, p. 1.
GERMANIER (R.). — **Locomotives bi-fréquence à redresseurs** livrées aux Chemins de fer fédéraux Suisses (C.F.F.). (1 200 mots & fig.)

1959 **621** .335 (494)
Bulletin Sécheron, nº 28 F, p. 5.
GERMANIER (R.). — **Locomotives diesel-électriques Em 3/3 de 600 ch** livrées aux Chemins de fer fédéraux Suisses (C.F.F.). (950 mots.)

Bulletin scientifique de l'Association des Ingénieurs électriciens sortis de l'Institut Electrotechnique Montefiore. (Liège.)

1959 **621** .315
Bull. scient. de l'Assoc. des Ing. électr. sortis de l'Institut Electrotechnique Montefiore, octobre, p. 605.
STÖCKEL (H.). — Méthodes modernes pour la **détermination de défauts de câbles.** (4 300 mots & fig.)

1959 **621** .331
Bull. scient. de l'Assoc. des Ing. électr. sortis de l'Institut Electrotechnique Montefiore, novembre, p. 635.
BAEYENS (F.). — Les **problèmes qui se posent à la jonction de deux réseaux de chemins de fer électrifiés dans des systèmes différents.** (5 200 mots & fig.)

1959 **621** .335
Bull. scient. de l'Assoc. des Ing. électr. sortis de l'Institut Electrotechnique Montefiore, novembre, p. 653.
LAMBERTS (P.). — Le **matériel de traction électrique polycourant.** (8 000 mots & fig.)

Bulletin de la Société Belge des Electriciens. (Bruxelles.)

1959 **621** .314
Bull. de la Soc. belge des Electriciens, octobre-décembre, p. 307.
SCHIRMAN (A.). — Les **semi-conducteurs** (Ge et Si) et leurs applications. (1 500 mots & fig.)

Bulletin de la Société Française des Electriciens. (Paris.)

1959 **621** .32
Bulletin de la Soc. Française des Electriciens, octobre, p. 597.
FLEURY (D.A.). — **Essais de catadioptres à grande distance.** (8 000 mots & fig.)

1959 **621** .315
Bulletin de la Soc. Française des Electriciens, décembre, p. 724.
ORGERET (L.) et RENAUD (J.). — Le **disjoncteur pneumatique à haute tension** et les vitesses de rétablissement de tension élevées, le défaut kilométrique. (8 200 mots & fig.)

Bulletin de la Société des Ingénieurs Civils de France. (Paris.)

1959 **531**
Bull. de la Soc. des Ing. Civils de France (mémoires), fasc. V, septembre-décembre, p. 305.
HANOCQ (Ch.). — Les lois de similitude dans le domaine de la **mécanique des fluides** appliquée à l'étude des machines. (7 000 mots & fig.)

Bulletin technique de la Suisse Romande. (Lausanne.)

1959 **625** .13 (494)
Bull. techn. de la Suisse Romande, 19 décembre, p. 393.
DESPONDS (R.). — Le **tunnel de Donnerbühl** à Berne. Construction d'un tunnel ferroviaire par la méthode du bouclier. (2 000 mots & fig.)

1959 **625** .13 (494)
Bull. techn. de la Suisse Romande, 19 décembre, p. 398.
BONNARD (D.) et RECORDON (E.). — **Etude expérimentale de la poussée des terres** sur le tunnel de Donnerbühl. (2 500 mots & fig.)

1960 **625** .13 (494)
Bull. techn. de la Suisse Romande, 2 janvier, p. 1.
PANCHAUD (F.) et RESCHER (O.J.). — Etude sur modèle par photo-élasticité de la **résistance d'une section type du tunnel de Donnerbühl.** (1 200 mots & fig.)

1960 **625** .13 (494)
Bull. techn. de la Suisse Romande, 2 janvier, p. 5.
KIPFER (P.) et WANZENRIED (H.). — Tunnel du Donnerbühl. **Calcul statique et fabrication des voussoirs.** (3 000 mots & fig.)

1960 **625** .13 (494)
Bull. techn. de la Suisse Romande, 2 janvier, p. 13.
RUPPANNER (H.). — La **construction du tunnel** du Donnerbühl par la méthode du bouclier. (2 000 mots & fig.)

Bulletin de l'Union Internationale des Chemins de fer. (Paris.)

1960 **385** .113 (495)
Bull. de l'Union Intern. des Chemins de fer, janvier, p. 9.
Les **Chemins de fer de l'Etat Hellénique** (1957-1958). (1 200 mots.)

C.F.F. (Berne.)

1960 **621** .3 (494)
C.F.F., janvier, p. 8.
NIEDERBERGER (H.). — Un **ordinateur électronique** aux C.F.F. (800 mots & fig.)

1960 **625** .14 (494)
C.F.F., janvier, p. 4.
PORTMANN (M.). — **Innovations intéressantes dans le domaine de la voie.** (2 000 mots & fig.)

Chemins de fer. (Paris.)

1959 **656** .222 .5 (44)
Chemins de fer, novembre-décembre, p. 154.
La **France** dite « **Economique** » **peut-elle être desservie totalement par des trains de matinée et de soirée ?** (3 000 mots & fig.)

1959 **621** .335 (42)
Chemins de fer, novembre-décembre, p. 160.
La première des **locomotives électriques à courant monophasé** 25 000 V, 50 Hz, de 3 690 ch, livrée aux British Railways par l'Associated Electrical Industries Limited. (1 000 mots & fig.)

1959 **625** .282 (44)
Chemins de fer, novembre-décembre, p. 164.
CAIRE (D.). — Les **nouvelles locomotives Diesel-électriques du type 040 DG** de 1 400 ch, construites pour la S.N.C.F. (1 200 mots & fig.)

1959 **621** .438 (44)
Chemins de fer, novembre-décembre, p. 167.
CAIRE (D.). — La **nouvelle locomotive à générateur à pistons libres, turbine à gaz,** transmission mécanique, construite par la Régie Nationale des Usines Renault avec la collaboration de la Compagnie des Ateliers et Forges de la Loire. (4 000 mots & fig.)

1959 **625** .1
Chemins de fer, novembre-décembre, p. 176.
PORCHER (B.). — Pourquoi et comment se pose problème de l'**entretien des voies.** (5 000 mots & fi

---

Génie Civil. (Paris.)

1959 6
Génie Civil, n° 3506, 15 décembre, p. 514.
ORLOWSKI (P.). — **L'application de la métallisati au zinc à la protection des ouvrages d'art.** (800 mot

---

1960 **621** .335 (64 + 6
Génie Civil, n° 3507, 1er janvier, p. 2.
PAPAULT (R.). — Les **locomotives CC de 3 400 à courant continu 3 000 V et récupération** des Chemi de fer Algériens et Marocains. (5 000 mots & fig.)

1960 **624**
Génie Civil, n° 3509, 1er février, p. 61.
MASSE (R.). — **Portiques doubles symétriques** sol cités par l'action d'efforts excentrés. (800 mots & fi

---

L'Ingénieur. (Montréal.)

1959 6
L'Ingénieur, 45e année, n° 180, p. 9.
CHAURET (Ed.). — **L'air dans le béton.** (3 000 mo & fig.)

Revue Electricité — Electrotechnique Généra (Bruxelles.)

1959 **621** .3
Revue Electricité — Electrotechnique Générale, Vol. n° 12, p. 339.
PHILIPPE (G.M.). — **Circuits équivalents des tra sistors.** (4 000 mots & fig.)

Revue Générale des Chemins de fer. (Pari

1960 **625** .172 (4
Revue Générale des Chemins de fer, janvier, p.
LÉVI (R.). — **Nouvelle évolution de l'entretien coura des voies.** (6 000 mots, tableaux & fig.)

1960 **625** .1 (44) & **627** .82 (4
Revue Générale des Chemins de fer, janvier, pp. 16 et 2
L'aménagement de la Durance.
I. Le **barrage** de Serre-Ponçon, par M.J. CABANIU (2 500 mots & fig.)
II. **Déviation de la ligne Veynes-Briançon entre Chorg et Embrun par suite de la construction du barrage Serre-Ponçon,** par M. MAURY. (4 000 mots & fi

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1960 **625** .26 (4
Revue Générale des Chemins de fer, janvier, p. 3
DOMINÉ. — **Le stockage et la manutention des b** au Magasin général de Romilly. (2 000 mots & fi

1960 **625 .216**
Revue Générale des Chemins de fer, janvier, p. 42.
LASSON (J.). — L'**attelage automatique** dans les chemins de fer. Réalisations et études en cours. (2 500 mots & fig.)

Revue de l'Union Internationale des Transports Publics. (Bruxelles.)

1959 **625 .212**
Revue de l'Union Intern. des Transp. Publics, n° 3-4, décembre, p. 219.
MAESTRELLI (R.). — **Pneumatic-tyred wheels** on Underground Railways. (4 000 mots & fig.)

1959 **625 .1 (460)**
Revue de l'Union Intern. des Transp. Publics, n° 3-4, décembre, p. 259.
Liaisons ferroviaires de Madrid. (1 200 mots & fig.)

Revue Universelle des Mines. (Liège.)

1960 **62 (01**
Revue Universelle des Mines, janvier, p. 18.
LOSSIER (H.). — Pathologie des **expertises techniques en matière de Génie civil.** (5 000 mots.)

La Traction Electrique dans les Chemins de fer. (Bruxelles.)

1960 **621 .335**
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, n° 1, janvier, p. 1.
MUSYCK (E.). — Etude d'un dispositif destiné à améliorer l'utilisation de l'adhérence d'une **locomotive électrique** à courant continu. *(Suite et fin.)* (4 000 mots & fig.)

1960 **621 .335 (485)**
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, n° 1, janvier, p. 17.
LILJEBLAD (J.) et BJÖRKLUND (B.). — La **locomotive électrique** pour trains rapides Ra des Chemins de fer de l'Etat suédois. (4 900 mots & fig.)

1960 **621 .337**
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, n° 1, janvier, p. 37.
PETROV (B.P.). — Utilisation du poids adhérent d'une rame électrique pendant le **démarrage et le freinage des moteurs de traction.** (2 200 mots & fig.)

1960 **621 .337**
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, n° 1, janvier, p. 44.
PFLUG (E.). — **Commande par variation de fréquence** pour l'exploitation par rames réversibles sur les Chemins de fer fédéraux allemands. (5 400 mots & fig.)

1960 **621 .332 (42)**
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, n° 1, janvier, p. 58.
Les **fondations le long de la voie** dans les régions exposées aux affaissements. (920 mots & fig.)

La Vie du Rail. (Paris.)

1959 **656 .2**
La Vie du Rail, 20 décembre, p. 2.
1960 - **Confiance en l'avenir du Rail.** (Interview de M. Ph. DARGEOU, Directeur Général de la S.N.C.F.) (3 000 mots & fig.)

1959 **656 .254**
La Vie du Rail, 20 décembre, p. 7.
LAURENT (F.). — Les **postes de commandement** à la S.N.C.F. (2 500 mots & fig.)

1959 **385 (09 (492)**
La Vie du Rail, 20 décembre, p. 41.
Chemins de fer aux Pays-Bas. (2 500 mots, carte & fig.)

1959 **621 .33 (43)**
La Vie du Rail, 27 décembre, p. 9.
Courte section, trafic important, ont motivé l'**électrification Hargarten-Ueberherrn.** (600 mots & fig.)

1959 **656 .222 .4**
La Vie du Rail, 27 décembre, p. 14.
Les **pointes du trafic ferroviaire** et leur incidence sur le transport des groupes. (1 500 mots & fig.)

1960 **656 .224**
La Vie du Rail, 3 janvier, p. 3.
PIOT (G.). — Comment fonctionne un grand **Central-Locations.** (500 mots & fig.)

In German.

Archiv für Eisenbahnwesen. (Berlin.)

1959 **385 (061 .5**
Archiv für Eisenbahnwesen, Heft 4, S. 472.
TUJA (J.). — Die schrittweise **Anpassung des Internationalen Eisenbahnverbandes an die heutigen Erfordernisse.** (11 000 Wörter.)

1959 **385 .11**
Archiv für Eisenbahnwesen, Heft 4, S. 495.
OTTMANN (K.). — **Neutralisierung der Wegekosten.** (8 000 Wörter.)

Die Bundesbahn. (Darmstadt und Köln.)

1959 **621 .431 .72**
Die Bundesbahn, Nr. 22, November, S. 1061.
WIENS (G.). — Geringster Aufwand-höchster Nutzen, Ziel der **Dieseltraktion.** (3 000 Wörter.)

1959 656 .21
Die Bundesbahn, Nr. 22, November, S. 1068.
JACOBSHAGEN (M.). — **Konzentration im Betriebsdienst.** (5 000 Wörter & Tabellen.)

1959 656 .1 (43)
Die Bundesbahn, Nr. 22, November, S. 1078.
HEUBEL (W.). — Der **motorisierte Strassen-Personenverkehr** im Jahre 1958. (4 000 Wörter & Tabellen.)

1959 385 .517 .7
Die Bundesbahn, Nr. 22, November, S. 1088.
KAMMERLING (K.). — Bedeutung, Aufgaben und Organisation der **Eisenbahn-Siedlungsgesellschaften.** (4 000 Wörter.)

1959 656 .2 (43)
Die Bundesbahn, Nr. 23, Dezember, S. 1115.
OEFTERING (H.M.). — **Bundesbahn und Marktwirtschaft.** (3 000 Wörter.)

1959 625 .28 (43)
Die Bundesbahn, Nr. 23, Dezember, S. 1123.
KLINGENSTEINER (J.) und EBNER (E.). — Der **Zugförderungsdienst** im Fahrplanjahr 1959-1960. (5 000 Wörter & Tabellen.)

1959 625 .113
Die Bundesbahn, Nr. 23, Dezember, S. 1139.
NEBELUNG (H.). — Das **Steigungsproblem bei Gebirgsbahnen.** (5 000 Wörter, Tabellen & Abb.)

Deutsche Eisenbahntechnik. (Berlin.)

1959 621 .135 .2
Deutsche Eisenbahntechnik, Dezember, S. 571.
BEER (H.) und SCHMITZ (G.). — Das **Flammenhärten der Spurkränze** an den führenden Radsätzen der Dampflokomotiven. (4 500 Wörter & Abb.)

1959 625 .28
Deutsche Eisenbahntechnik, Dezember, S. 579.
PURITZ (F.) und SCHMIDTKE (H.). — Stand der **Entwicklung von Gleisbremsen** zur Abstands- und Laufzielbremsung bei der Deutschen Reichsbahn. (5 000 Wörter & Abb.)

1959 656 .224
Deutsche Eisenbahntechnik, Dezember, S. 587.
ECKERT (J.). — **Von der Schaffnerzange zum Automaten.** (3 500 Wörter & Abb.)

1959 656 .22
Deutsche Eisenbahntechnik, Dezember, S. 597.
BERNGARD (K.A.) und HAMMER (W.). — Theorie und Praxis der **Fernzugbildung** in der Sowjetunion. (3 000 Wörter & Abb.)

1959 625 .23
Deutsche Eisenbahntechnik, Dezember, S. 603.
COSTA (R.). — Moderne und leichte Werkstoffe für die **Ausstattung von Reisezugwagen.** (1 000 Wörter & Abb.)

1959 625 .113
Deutsche Eisenbahntechnik, Dezember, S. 607.
KNOBLOCH (E.). — Die **Ermittlung des notwendigen lichten Raumes bei kurzen Bogen,** insbesondere bei Gegenbogen. (1 000 Wörter & Abb.)

Der Eisenbahningenieur. (Frankfurt am Main.)

1959 621 .392
Der Eisenbahningenieur, Dezember, S. 357.
BEYER (H.). — **Gefüge und Festigkeit der Gusseisenschweissung und -lötung.** (2 000 Wörter, Tabellen & Abb.)

1959 621 .7
Der Eisenbahningenieur, Dezember, S. 362.
CREMER (F.). — Das **Metallspritzverfahren.** (4 000 Wörter & Abb.)

1959 621 .431 .72
Der Eisenbahningenieur, Dezember, S. 367.
HARTMANN (W.). — **Ausbesserung von Dieseltriebzügen und Diesellokomotiven** in Leichtbauweise. (2 000 Wörter & Abb.)

1959 625 .162
Der Eisenbahningenieur, Dezember, S. 370.
SPÖRLEIN (G.). — **Prüfung der beschrankten Bahnübergänge.** (3 000 Wörter.)

1959 526
Der Eisenbahningenieur, Dezember, S. 378.
LORKE (B.) und MOSSMANN (G.). — Der **Basisentfernungsmesser « Todis »** und sein Einsatz bei der Deutschen Bundesbahn. (2 000 Wörter & Abb.)

E.T.R.-Eisenbahntechnische Rundschau. (Köln-Darmstadt.)

1959 656 .225
Eisenbahntechnische Rundschau, Dezember, S. 505.
BODE (W.). — **Gebrochener Verkehr,** vorzugsweise in technischer Sicht. (8 000 Wörter & Abb.)

1959 656 .225
Eisenbahntechnische Rundschau, Dezember, S. 519.
SELZ (L.). — Die **Fahrerschütterungen eines Transportguts** auf Eisenbahn und Strasse. (3 000 Wörter & Abb.)

1959 625 .28 (43)
Eisenbahntechnische Rundschau, Dezember, S. 525.
HARRES (H.). — Wirtschaftliche und technische Auswirkungen des **Strukturwandels im Zugförderungsdienst** bei der Deutschen Bundesbahn. (6 000 Wörter, Tafeln & Abb.)

1959 625 .13
Eisenbahntechnische Rundschau, Dezember, S. 536.
SPANG (J.). — **Tunnelneubau in druckhaftem und gebrächem Gebirge.** (4 000 Wörter & Abb.)

1959 **625 .251**
Eisenbahntechnische Rundschau, Dezember, S. 544.
POLZIN (G.). — Der **Bremsklotz** — ein Faktor der Sicherheit des Bahnbetriebes. (1 500 Wörter & Abb.)

Elektrische Bahnen. (München.)

1959 **621 .31 (43)**
Elektrische Bahnen, Heft 12, S. 265.
HARZ (H.) und TITTEL (J.). — Die **neuen gleitenden Netzkupplungsumformer** der Deutschen Bundesbahn für 50/16 2/3 Hz, 25 MVA in Karlsruhe und Köln. (9 500 Wörter & Abb.)

1959 **621 .335 (494)**
Elektrische Bahnen, Heft 12, S. 282.
HAURI (M.). — Die **neue Lokomotive Ae 8/8 Nr. 271** der Bern-Lötschberg-Simplon-Bahn. (750 Wörter & Abb.)

Elektrotechnik und Maschinenbau. (Wien.)

1960 **621 .31**
Elektrotechnik und Maschinenbau, 1. Januar, S. 3; 15. Januar, S. 31; 1. Februar, S. 56.
FERSCHL (L.). — **Neuere Entwicklungen auf dem Generatorschutzgebiet.** (12 000 Wörter & Abb.)

1960 **621 .31**
Elektrotechnik und Maschinenbau, 1. Februar, S. 49.
HAYEK (E.). — Der **Schalttransduktor** als Bauelement des Dreipunktreglers. (3 000 Wörter & Abb.)

1960 **621 .316**
Elektrotechnik und Maschinenbau, 1. Februar, S. 52.
BEN URI (J.), WALLACH (Y.) und EILATH (E.). — Krämer-Kaskade mit **Trockengleichrichtern.** (2 500 Wörter & Abb.)

E.T.Z. — Elektrotechnische Zeitschrift. (Berlin.)

1959 **621 .31**
E.T.Z. Elektrotechnische Zeitschrift, 21. Dezember, S. 471.
SCHUMM (E.). — **Fernauslösung von Hochspannungsschaltern durch Trägerfrequenzsignale.** (2 000 Wörter & Abb.)

1960 **621 .35**
E.T.Z. Elektrotechnische Zeitschrift, 11. Januar, S. 7.
DEMELT (K.). — **Gasdichte Nickel-Kadmium- Akkumulatoren.** (1 500 Wörter & Abb.)

1960 **621 .316**
E.T.Z. Elektrotechnische Zeitschrift, 25. Januar, S. 29.
FEINDT (H.). — **Neuzeitliche Hochspannungs-Hochleistungs-Schmelzsicherungen.** (3 500 Wörter & Abb.)

1960 **621 .31**
E.T.Z. Elektrotechnische Zeitschrift, 8. Februar, S. 53.
FRANKEN (H.). — Die **Messung von Kontaktprellungen bei Schaltgeräten.** (1 500 Wörter & Abb.)

1960 **621 .31**
E.T.Z. Elektrotechnische Zeitschrift, 8. Februar, S. 56.
MENDE (Herbert G.). — Über **Kaltkathodenröhren** und ihre Anwendungen. (5 400 Wörter & Abb.)

Europa Verkehr. (Darmstadt.)

1959 **656 .222 .6 (47 + 73)**
Europa Verkehr, Heft 4, S. 175.
SOMMER (G.). — Der **Güterverkehr der UdSSR und der USA** : eine vergleichende Studie. (1 500 Wörter & Tafeln.)

1959 **656**
Europa Verkehr, Heft 4, S. 203.
ELLERSIEK (K.). — Wirtschaftliche Strukturwandlungen. Ihre Auswirkungen auf die **Rationalisierung des Güterverkehrs** und den Materialfluss. (2 000 Wörter & Abb.)

Glasers Annalen. (Berlin.)

1959 **621 .431 .72 (494)**
Glasers Annalen, November, S. 377.
SCHLÄPFER (O.). — **Entwicklungstendenzen im Bau von Dieselfahrzeugen** in der Schweiz. (5 000 Wörter, Tafeln & Abb.)

1959 **621 .431 .72 (436)**
Glasers Annalen, November, S. 389.
SCHÖFFL (E.). — **Stand der Dieselzugförderung** und ihre Technik bei den Österreichischen Bundesbahnen. (5 000 Wörter & Abb.)

1959 **621 .431 .72 (44)**
Glasers Annalen, November, S. 401.
TOURNEUR (Ch.). — Die **Entwicklung des Dieselbetriebes** auf den Französischen Eisenbahnen. (4 000 Wörter & Abb.)

1959 **621 .335**
Glasers Annalen, November, S. 409.
GLADIGAU (A.). — **Anwendung von Transduktoren und Transistoren in elektrischen Lokomotiven.** (3 500 Wörter & Abb.)

Henschel-Nachrichten. (Kassel.)

1959 **621 .131 .2**
Henschel-Nachrichten, Nr. 6, Dezember, S. 2.
Die **Entwicklung zum selbsttragenden Lokomotiv-Aufbau in Stahl-Leichtbauweise** bei den Henschel-Werken. (1 000 Wörter, Tafeln & Abb.)

Internationales Archiv für Verkehrswesen. (Mainz.)

1959 **385 .1 (43)**
Internat. Archiv für Verkehrswesen, Novemberheft, S. 353.
FRITSCHE (H.). — **Abbau des Defizits der Deutschen Bundesbahn durch radikalen Strukturwandel.** (7 000 Wörter & Tafeln.)

1959 **656** (4)
Internat. Archiv für Verkehrswesen, Novemberheft, S. 363.
Gegenüberstellung verkehrspolitischen Regelungen im europäischen Ländern. (8 000 Wörter.)

1959 **388** (43)
Internat. Archiv für Verkehrswesen, Dezemberheft, S. 389.
LEHNER (F.). — **Probleme des öffentlichen Massenverkehrs** und Wege zu ihrer Lösung in den deutschen Grosstädten. (7 000 Wörter & Abb.)

1959 **614** .8
Internat. Archiv für Verkehrswesen, Dezemberheft, S. 401.
von AMMON (M.). — Die **Sicherheit der Verkehrsmittel** auf der Schiene, auf der Strasse und in der Luft. (3 500 Wörter & Abb.)

Leichtbau der Verkehrsfahrzeuge. (Frankfurt-Main.)

1959 **625** .212
Leichtbau der Verkehrsfahrzeuge, November-Dezember, S. 223.
BODEY (A.). — Über die **Belastbarkeit von klotzgebremsten kleinen Eisenbahnrädern** mit aufgeschrumpften Radreifen. (2 000 Wörter & Abb.)

1960 **625** .212
Leichtbau der Verkehrsfahrzeuge, Januar-Februar, S.2.
SCHRÖDER (E.). — Die **Bedeutung des kleinen Rades für Schienenfahrzeuge.** (1 500 Wörter.)

1960 **625** .212
Leichtbau der Verkehrsfahrzeuge, Januar-Februar, S. 4.
RAUTENBERG (W.). — **Statische und dynamische Dehnungsspannungsmessungen an Eisenbahnrädern.** (5. Teil.) (6 000 Wörter & Abb.)

1960 **625** .212
Leichtbau der Verkehrsfahrzeuge, Januar-Februar, S. 16.
ECKHARDT. — Vorschläge für die **Typenbildung der Wagenradsätze** mit kleinem Laufkreisdurchmesser. (3 000 Wörter & Abb.)

1960 **625** .212
Leichtbau der Verkehrsfahrzeuge, Januar-Februar, S. 24.
WNUKOWSKY (C.). — Der **Einfluss des Rollvorganges auf die Laufflächen von Eisenbahnrädern** mit kleinem Laufkreisdurchmesser. (2 500 Wörter & Abb.)

Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik. (Zürich.)

1959 **656**
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Nr. 4, S. 283.
HUTTER (R.). — La **coordination des investissements dans le domaine des transports.** (6 000 Wörter.)

1959 **65**
Schweizerisches Archiv für Verkehrswissenschaft un Verkehrspolitik, Nr. 4, S. 302.
BAUMGARTNER (J.-P.) — Les **transports et l'activité économique.** (3 000 Wörter & Abb.)

1959 **65**
Schweizerisches Archiv für Verkehrswissenschaft un Verkehrspolitik, Nr. 4, S. 313.
KASPAR (C.). — Der **Produktivitätsbegriff i Verkehr.** (4 000 Wörter & Tabellen.)

Siemens-Zeitschrift. (Berlin.)

1959 **621** .3
Siemens-Zeitschrift, Dezember, S. 780.
TROGER (H.). — Der **neue 110-kV-Expansion schalter** für 16 2/3-Hz-Bahnnetze. (3 200 Wörter & Abb.

1960 **621** .31
Siemens-Zeitschrift, Januar, S. 31.
WEILAND (E.). — **Anlagenbildsteuerung** — ei neues Steuersystem für Schaltanlagen. (4 600 Wörte & Abb.)

1960 **621** .31
Siemens-Zeitschrift, Januar, S. 53.
MEYER (F.). — Die **Beherrschung von Kurzschluss lichtbogen** in offenen und gekapselten Mittelspannung schaltanlagen. (5 000 Wörter & Abb.)

Signal und Draht. (Frankfurt am Main.)

1959 **656** .25
Signal und Draht, Dezember, S. 189.
GRUBER (H.). — **Abzweigung von Trägerfrequen kanälen bei Vorgruppensystemen.** (3 000 Wörter & Abb

---

1959 **625** .1
Signal und Draht, Dezember, S. 194.
LEONHARD (E.). — Die einheitliche **Isolierung d Weichen und Gleise.** (4 000 Wörter & Abb.)

1960 **656** .254 (4
Signal und Draht, Januar, S. 1.
SCHEPP (A.). — Das **Funksprechgerät Teleport** und seine Verwendung bei der Deutschen Bundesbah (1 600 Wörter & Abb.)

1960 **656** .25 (4
Signal und Draht, Januar, S. 7.
FRANITZA (P.). — Die **Signalanlagen der Nor Süd-Bahn** im Rheinischen Braunkohlenrevier. (2 000 Wörter & Abb.)

In English.

Electric Traction on the Railways. (Brussels.)

1960 **621** .335
Bulletin of the International Railway Congress Association. — Electric Traction on the Railways, No. 1, January, p. 1.
MUSYCK (E.). — Investigation of a device designed to improve the utilisation of the adhesion of an **electric D.C. locomotive.** *(To be continued.)* (4 500 words & fig.)

1960 **621** .33
Bulletin of the International Railway Congress Association. — Electric Traction on the Railways, No. 1, January, p. 12.
BERNARD. — The study of **electric traction problems** with the aid of mechanical integrators or electronic calculators. (4 700 words & fig.)

1960 **621** .351
Bulletin of the International Railway Congress Association. — Electric Traction on the Railways, No. 1, January, p. 27.
LIEBHAFSKY (H.A.) and DOUGLAS (D.L.). — The fuel cell. (3 000 words & fig.)

1960 **621** .431 (72)
Bulletin of the International Railway Congress Association. — Electric Traction on the Railways, No. 1, January, p. 36.
Wheel slip-and-slide detection. (1 750 words & fig.)

1960 **621** .431 .72 (47)
Bulletin of the International Railway Congress Association. — Electric Traction on the Railways, No. 1, January, p. 43.
Russian 3 000-HP **Diesel-electric** goods locomotive. (1 600 words & fig.)

Electrical Engineering. (New York.)

1959 **621** .333
Electrical Engineering, November, p. 1096.
LARSON (R.L.). — **A high-capacity maintenance-free generating system for motor coaches.** (4 600 words & figs.)

1959 **537** .4
Electrical Engineering, December, p. 1169.
LINCKS (G.F.). — **Improved standardization procedure as developed for lightning arresters.** (1 600 words & fig.)

1960 **656** .25 (73)
Electrical Engineering, January, p. 65.
SIBLEY (H.C.). — **Communication systems for railway traffic control.** (600 words.)

The Engineer. (London.)

1959 **621** .335 (42)
The Engineer, December 4, p. 745.
Main line A.C. locomotive. (2 000 words & figs.)

1959 **621** .431 .72 (42)
The Engineer, December 11, p. 768.
NOCK (O.S.). — **1 000 HP Diesel-electric locomotive** (2 000 words & figs.)

1959 **625** .4 (42)
The Engineer, December 25, p. 852.
Improved Underground trains. (1 000 words & figs.)

1959 **656** .25 (42)
The Engineer, December 25, p. 853.
Resignalling on the Southern Region. (4 200 words & figs.)

1959 **656** .225
The Engineer, December 25, p. 869.
Powdered freight handling equipment. (300 words & fig.)

Engineering. (London.)

1959 **621** .431 .72 & **621** .438
Engineering, September 18, p. 234.
COX (E.S.). — **Application of diesel engines and gas turbines to rail transport.** (3 600 words & tables.)

1959 **669**
Engineering, November 20, p. 515.
SCHNURMANN (R.). — **Penetrants for non-destructive testing.** (3 200 words & figs.)

1960 **625** .13 (42)
Engineering, January 22, p. 114.
Modernizing an 1875 bridge. (1 900 words & figs.)

Indian Railways. (New Delhi.)

1959 **656** .2 (54)
Indian Railways, December, p. 777.
MATHUR (K.B.). — **Railways have turned the corner.** (2 400 words & figs.)

1959 **656** .2 (493)
Indian Railways, December, p. 793.
DE VOS (M.). — **Ten-year rehabilitation plan will modernise Belgian Railways.** (2 000 words.)

1959 **385** (061
Indian Railways, December, p. 797.
KOSTER (J.P.). — **ORE's international character.** (1 200 words & figs.)

Journal, The Institution of Locomotive Engineers. (London.)

1960 **621** .431 .72
Journal, The Institution of Locomotive Engineers, Vol. 49, Part No. 3, p. 276.
SCHUR (T.). — **Some design considerations of main line Diesel locomotives.** (86 pages, illustrated.)

1960 **621** .431 .72
Journal, The Institution of Locomotive Engineers, Vol. 49, Part No. 3, p. 361.
MAHY (G.R.). — **The design and construction of the two Derby Diesel-electric locomotives.** (28 pages, illustrated.)

Journal of the Institute of Transport. (London.)

1960 **656**
Journal of the Institute of Transport, January, p. 223.
GRUMBRIDGE (J.L.), TAIT (A.W.) and CARLING (A.F.R.). — **Fares structures : Air, Rail, Road.** (6 000 words.)

Modern Transport. (London.)

1960 **625** .42 (42)
Modern Transport, January 23, p. 11.
Picadilly Line. — First of 76 new trains built by Metropolitan-Cammell. (1 200 words & figs.)

1960 **656** (42)
Modern Transport, January 23, p. 6.
DUNNETT (L.J.). — **Government and roads and road transport. 4.-Future.** (800 words.)

1960 **656** (42)
Modern Transport, January 23, p. 12.
The problem of the peak. Rail and road aspects. *(Continued.)* (500 words.)

1960 **625** .142 .4 (42)
Modern Transport, January 23, p. 14.
Concrete sleepers. — Electrical properties. (300 words.)

The Oil Engine. (London.)

1959 **621** .431 .72 (498)
The Oil Engine, December, p. 202.
Rumanian State Railways orders **Sulzer-powered 2 100 HP Co + Co locomotives** to be built in Switzerland and Rumania. (1 600 words & figs.)

1960 **621** .431 .72 (9)
The Oil Engine, January, p. 242.
Railway progress in the Antipodes. (1 800 words & tables.)

The Overseas Engineer. (London.)

1960 **621** .335 (42)
The Overseas Engineer, January, p. 116.
Main-line A.C. locomotive. (700 words & fig.)

Journal, The Permanent Way Institution. (Tonbridge.)

1959 **625** .172 (43)
Journal, The Permanent Way Institution, December, p. 186.
BETHÄUSER (A.). — **Drainage and stabilization of track, cuttings and embankments on the German Federal Railways.** (1 900 words & figs.)

Permanent Way. (Tokyo.)

1959 **625** .143 .3
Permanent Way, No. 3, November, p. 9.
AKIRA YAGI. — **The abrasion of rail and tyre hardened by high frequency induction (in dry condition).** (2 200 words & figs.)

1959 **625** .144 .1
Permanent Way, No. 3, November, p. 19.
YOSHIO SHINOHARA. — **The economical length of a long rail.** (2 400 words & figs.)

Railway Age. (New York.)

1959 **656** .227 (73)
Railway Age, November 23, p. 20.
KIZZIA (J.W.). — **Shipping the atom : Railroad challenge and opportunity.** (2 000 words & figs.)

The Railway Gazette. (London.)

1959 **621** .431 .72 (42)
The Railway Gazette, November 20, p. 455.
Diesel maintenance depot at Cambridge, Eastern Region. (1 200 words & figs.)

1959 **621** .33 (42)
The Railway Gazette, November 20, p. 460.
Overhead electrification of sidings in the Southern Region. (600 words.)

1959 **625** .215
The Railway Gazette, November 20, p. 483; December 11, p. 538; December 25, p. 598.
KOFFMANN (J.L.). — **The riding properties of bogie vehicles.** (7 400 words & figs.)

1959 **625** .25
The Railway Gazette, November 20, p. 492.
Lightweight brake equipment. (1 600 words & figs.)

1959 **625** .142 (42)
The Railway Gazette, December 4, p. 510.
HUBBARD (W.). — **Railway sleepers in asbestos cement.** (1 200 words & figs.)

1959 **621** .335 (42)
The Railway Gazette, December 4, p. 515.
First A.C. electric locomotive for British Railways. (1 800 words & figs.)

1959 **621** .431 .72 (498)
The Railway Gazette, December 11, p. 541.
Diesel-electric locomotives for Roumania. (1 200 words & figs.)

1959 **621** .33 (42)
The Railway Gazette, December 18, p. 568.
Progress of electrification in the Scottish Region. (2 600 words & figs.)

1959 **656** .25 (68)
The Railway Gazette, December 25, p. 602.
Remote control and C.T.C. on South African Railways. (1 200 words & figs.)

1960 **656** .222 (42)
The Railway Gazette, January 1, p. 11.
HICK (F.L.). — **Diesel multiple-unit operation in the North Eastern Region.** (2 400 words, tables & figs.)

1960 **656** .225
The Railway Gazette, January 8, p. 42.
Use of containers for all merchandise traffic. (1 800 words & figs.)

1960 **625** .232 (42)
The Railway Gazette, January 8, p. 46.
Restaurant cars for British Railways. (1 400 words & figs.)

Diesel Railway Traction. (London.)

1959 **621** .431 .72
Diesel Railway Traction, December, p. 463.
Sulzer engine regulation system. (1 800 words & figs.)

1959 **621** .431 .72
Diesel Railway Traction, December, p. 471.
Railbuses with air suspension of body. (1 700 words & figs.)

1959 **621** .438 (47)
Diesel Railway Traction, December, p. 474.
Soviet gas-turbine locomotive design. (900 words & figs.)

1960 **621** .431 .72 (44)
Diesel Railway Traction, January, p. 3.
New French standard locomotives. (1 200 words & figs.)

1960 **621** .431 .72 (62)
Diesel Railway Traction, January, p. 7.
Diesel traction development in Egypt. (2 600 words & figs.)

Railway Locomotives and Cars. (New York.)

1959 **625** .245 (71)
Railway Locomotives and Cars, November, p. 27.
CNR cuts piggyback car weight. (300 words & figs.)

1959 **621** .431 .72 (73)
Railway Locomotives and Cars, November, p. 34.
Winterizing steam generators. (1 400 words & figs.)

1959 **625** .246 (73)
Railway Locomotives and Cars, November, p. 38.
Safety and comfort in cabooses. (800 words & figs.)

1959 **625** .28 (73)
Railway Locomotives and Cars, December, p. 22.
C & NW starts « push-pull » service. (3 000 words & figs.)

Railway Signaling and Communications. (New York.)

1959 **656** .25 (73)
Railway Signaling and Communications, November, p. 20.
Burlington adds dispatcher control on wayside radio stations. (3 000 words & figs.)

1959 **656** .25 (73)
Railway Signaling and Communications, December, p. 19.
P and LE installs multiple track C.T.C. (2 400 words & figs.)

1959 **656** .25 (73)
Railway Signaling and Communications, December, p. 22.
Monorail is signaled electronically. (1 000 words & figs.)

1959 **651** (73)
Railway Signaling and Communications, December, p. 26.
How railroads use computers. (2 900 words & fig.)

Railway Steel Topics. (Sheffield.)

1959 **62** (01
Railway Steel Topics, Vol. 5, No. 2, p. 15.
de ANDA (A.). — **Occasional fractures of railway axles below wheel hubs.** (1 500 words.)

1959 **624**
Railway Steel Topics, Vol. 5, No. 2, p. 19.
ROBERTSON (V.A.M.). — **The modern trend in the design of railway bridges.** (1 200 words.)

In Spanish.

Ferrocarriles y Tranvias. (Madrid.)

1959 **625** .42 (460)
Ferrocarriles y Tranvias, vol. 25-X, nº 290, p. 338.
PLANELL (F.). — El ramal Sagrera-Horta de las **lineas metropolitanas de Barcelona.** (2 000 palabras & fig.)

1959 **656** .223 .2 (460)
Ferrocarriles y Tranvias, vol. 25-X, nº 290, p. 345.
SANCHEZ GAMBORINO (F.-M.). — La nueva **reglamentacion de vagones particulares.** (2 000 palabras.)

1959 **621** .332 (460)
Ferrocarriles y Tranvias, vol. 25-XI, nº 291, p. 376.
PEREZ MORALES (G.). — **Nueva catenaria** tipo RENFE, V. *(Continuarà.)* (2 000 palabras & fig.)

1959 **621** .137
Ferrocarriles y Tranvias, vol. 25-XI, nº 291, p. 383.
PAUL DE GOYENA (J.-M.). — **Repeticion discontinua di informacion en una locomotora.** (1 500 palabras & fig.)

Revista de Ciencia Aplicada. (Madrid.)

1959 **621** .3
Revista de Ciencia Aplicada, noviembre-diciembre, p. 481.
CODINA VIDAL (J.M.). — Estudio y realizacion de un **estabilizador de tension alterna.** (5 000 palabras & fig.)

In Hungarish (= 494.511).

Közlekedéstudományi Szemle. (Budapest.)

1959 **625** .28 = 494 .511
Közlekedéstudományi Szemle, janvier-février, p. 8.
PARKAI (I.). — Le **développement des systèmes de traction ferroviaire.** (4 200 mots.)

1959 **625** .143 (439) = 494 .511
Közlekedéstudományi Szemle, janvier-février, p. 28.
UNYI (B.). — Sur les problèmes de l'**application de la superstructure ferroviaire à barres longues** en Hongrie. (8 000 mots & fig.)

1959 **656** .226 = 494 .511
Közlekedéstudományi Szemle, janvier-février, p. 65.
SZANTO (E.). — La distance d'acheminement économiquement efficace des **trains de camions.** (3 200 mots & fig.)

In Italian.

Giornale del Genio Civile. (Roma.)

1959 **721** .
Giornale del Genio Civile, novembre, p. 945.
CALLARI (C.E.). — Sviluppo e controllo di u **calcolo approssimato di volte sottili cilindriche.** (7 00 parole, tabelle & fig.)

Ingegneria Ferroviaria. (Roma.)

1959 **656** .22
Ingegneria Ferroviaria, novembre, p. 966.
DAVITE (A.). — Proprietà di **struttura delle matric degli itinerari.** (1 500 parole & fig.)

1959 **621** .431 .72 (45
Ingegneria Ferroviaria, novembre, p. 969.
CAMPOSANO (P.) & BRANDANI (V.). — L **locomotive Diesel gruppi 341 e 342** delle Ferrovie dell Stato. Caratterische di prestazione risultate dai rilie dinamometrici. (6 000 parole, tabelle & fig.)

1959 **621** .33
Ingegneria Ferroviaria, novembre, p. 993.
PROSPERI (L.). — **L'influenza dannosa delle sovra tensioni atmospheriche sulla efficienza delle linee di contatt** nel sistema a c.c. 3 kV e mezzi cui si ricorre per limitarl (3 000 parole & fig.)

1959 **625** .142 .4 (4
Ingegneria Ferroviaria, novembre, p. 1001.
FOTI (F.). — **Impiego di traverse cementizie** sull rete ferroviaria italiana. (1 500 parole & fig.)

1959 **385** .11
Ingegneria Ferroviaria, novembre, p. 1008.
SAVOJA (A.). — I **costi marginali** dei trasporti ferr viari. (3 000 parole.)

Politica dei Trasporti. (Roma.)

1959 **625** .42 (4
Politica dei Trasporti, dicembre, p. 480.
PATRASSI (A.). — I progetti della **rete metr politana** di Roma. (3 000 parole & fig.)

1959 **385** (061
Politica dei Trasporti, dicembre, p. 489.
CUTTICA (A.). — **L'O.R.E.** l'Ufficio Ricerche Prove delle ferrovie europee. (2 000 parole.)

Trasporti Pubblici. (Roma.)

1959 **621** .
Trasporti Pubblici, luglio-agosto, p. 1037.
DEVAUX (P.). — **Pourquoi les lampes électriqu peuvent-elles avoir une durée insuffisante ?** (8 000 paro & fig.)

1959 621 .335 (45)
Trasporti Pubblici, ottobre, p. 1451.
DARD (M.). — Gli **elettrotreni delle serie ETR 220 e ETR 240.** (2 000 parole & fig.)

In Netherlands.

De Ingenieur. (Den Haag.)

1960 656 .223 .2 (4)
De Ingenieur, nr 2, 8 januari, p. V. 1.
DE STEENWINKEL (F.G.). — De **Europese Goederenwagenpool** « EUROP ». (4 000 woorden.)

1960 621 .3
De Ingenieur, nr 5, 29 januari, p. E. 1.
FRITZSCHE (W.). — **Transistoren in der Steuerungs- und Regelungstechnik.** (2 000 woorden & fig.)

Spoor- en Tramwegen. (Den Haag.)

1959 656 .222 .5 (4)
Spoor- en Tramwegen, nr 25, 3 december, p. 401.
VAN DER ELST (P.). — **Symmetrie in de dienstregeling.** Buitenlandse verbindingen. (800 woorden.)

1959 656 .224
Spoor- en Tramwegen, nr 26, 17 december, p. 417.
HARMSEN (B.T.). — **Avondposttreinen.** (2 000 woorden & fig.)

1959 656 .222
Spoor- en Tramwegen, nr 26, 17 december, p. 420.
VAN DER ELST (P.). — **Symmetrie in de dienstregeling.** Binnenlandse verbindingen. (1 500 woorden.)

1959 385 (09 .3 (492)
Spoor- en Tramwegen, nr 26, 17 december, p. 423; nr 27, 31 december, p. 440.
LANDSKROON (F.P.A.). — **Beknopte geschiedenis der spoorwegen in** Nederland. X.-XI. (4 000 woorden & fig.)

1959 385 (09 (94)
Spoor- en Tramwegen, nr 26, 17 december, p. 426.
VAN BIJNEN (J.). — De **spoorwegen van Australië.** The Queensland Railways. (1 200 woorden & fig.)

In Polish (= 491.85).

Przeglad Kolejowy. (Varsovie.)

1959 656 .2 (06 = 491 .85
Przeglad Kolejowy, janvier, p. 5.
WYRZYKOWSKI (W.). — Les questions d'**exploitation des chemins de fer** au Congrès de Madrid 1958. (2 700 mots.)

1959 625 .2 (06 = 491 .85
Przeglad Kolejowy, janvier, p. 10.
NEUMANN (T.). — Sessions de la **Section « Matériel et Traction »** pendant le Congrès de Madrid. (3 200 mots.)

1959 625 .14 (06 = 491 .85
Przeglad Kolejowy, janvier, p. 16.
SOCHACKI (K.). — Les **questions de la voie** au XVIIe Congrès des Chemins de fer. (2 800 mots.)

1959 621 .335 = 491 .85
Przeglad Kolejowy, janvier, p. 24.
ROMANISZYN (Z.). — Observations sur le thème concernant le **calcul et la construction des essieux des locomotives électriques à commande individuelle.** (2 200 mots & fig.)

1959 625 .234 = 491 .85
Przeglad Kolejowy, janvier, p. 29.
PIASTOWSKI (J.). — Le **conditionnement de l'air** dans les voitures de voyageurs. (1 200 mots & fig.)

1959 625 .216 = 491 .85
Przeglad Kolejowy, février, p. 47.
SOBOLEWSKI (H.). — **Etude des chocs centraux sur les appareils de choc** entre la caisse et le châssis des bogies de la locomotive électrique Bo-Bo. (3 600 mots & fig.)

1959 621 .43 = 491 .85
Przeglad Kolejowy, mars, p. 81.
ZEMBRZUSKI (K.). — Sur la question du **choix des paramètres des moteurs à combustion interne** pour les véhicules roulant sur rail. (5 500 mots & fig.)

1959 656 .254 (438) = 491 .85
Przeglad Kolejowy, mars, p. 93.
GODWOD (J.). — L'état actuel et le développement envisagé des **télécommunications** en Pologne. (2 500 mots.)

1959 621 .133 = 491 .85
Przeglad Kolejowy, mars, p. 98.
WOLFRAM (T.). — Quelques problèmes de modernisation du **dispositif de tirage des chaudières de locomotives.** (3 500 mots.)

1959 621 .3 = 491 .85
Przeglad Kolejowy, mars, p. 121.
WAZYNSKI (T.) & DABROWA-BAJON (M.). — Les paramètres temporaires durant les commandes de parcours dans les **appareils de commande.** (3 000 mots.)

In Portuguese.

Gazeta dos Caminhos de ferro. (Lisboa.)

1960 385 (09 .3 (469)
Gazeta dos Caminhos de ferro, nº 1730, 16 de Janeiro, p. 555.
de QUADROS ABRAGAO (F.). — **No Centenário dos Caminhos de ferro em Portugal.** Algunas notas sobre a sua história. *(Continua.)* (1 500 palavras.)

In Russian (= 491.7).

Jelesnodorosnuy Transporte. (Moscou.)

1959 **621** .33 = 491 .7
Jelesnodorosnuy Transporte, janvier, p. 8.
LOMAGUINE (N.A.). — **Questions actuelles concernant l'électrification des chemins de fer en courant alternatif 50 Hz.** (2 900 mots.)

1959 **656** .2 = 491 .7
Jelesnodorosnuy Transporte, janvier, p. 19.
BASOV (A.V.). — **Méthodes d'amélioration de l'utilisation des moyens de transport** et du débit des lignes ferroviaires. (2 600 mots & fig.)

1959 **656** .222 .4 = 491 .7
Jelesnodorosnuy Transporte, janvier, p. 25.
KIRYANOVA (O.S.) & LEPNYEV (M.I.). — Comment perfectionner les **graphiques des trains.** (2 500 mots & fig.)

1959 **656** .222 .1 = 491 .7
Jelesnodorosnuy Transporte, janvier, p. 30.
KOTOV (G.W.). — L'efficacité de l'augmentation de la **vitesse des trains de voyageurs.** (2 800 mots & fig.)

1959 **621** .431 .72 = 491 .7
Jelesnodorosnuy Transporte, janvier, p. 49.
KLEBNIKOV (G.K.). — L'intérêt technique et économique de l'**application du gaz naturel à la traction Diesel.** (2 150 mots & fig.)

1959 **656** .2 = 491 .7
Jelesnodorosnuy Transporte, janvier, p. 59.
KOUTIKOVA (H.A.). — La **cybernétique** et son domaine d'application dans les transports. (3 600 mots & fig.)

1959 **625** .1 = 491 .7
Jelesnodorosnuy Transporte, février, p. 15.
BAGAÏEV (S.I.). — Les **nouvelles constructions ferroviaires,** la réduction de leurs frais et l'augmentation de leur qualité. (3 800 mots.)

1959 **385** .5 (47) = 491 .7
Jelesnodorosnuy Transporte, février, p. 22.
TCHEREDNITCHENKO (E.T.). — **Mieux-être matériel des cheminots soviétiques.** (3 500 mots.)

1959 **625** .142 .4 = 491 .7
Jelesnodorosnuy Transporte, février, p. 34.
CHOULGA (V.Y.) & CHOULGA (A.M.). — **L'intérêt de la voie à barres longues sur les traverses en béton armé.** (1 700 mots.)

1959 **621** .3 = 491 .7
Jelesnodorosnuy Transporte, février, p. 52.
SEMENOV (N.M.). — Le **développement de l'automatisation,** de la télémécanique et des télécommunications. (2 200 mots & fig.)

1959 **656** .222 .4 = 491 .7
Jelesnodorosnuy Transporte, février, p. 62.
VOROBUYEV (N.A.). — Certaines questions sur la **construction des horaires graphiques** de trains sur les lignes surchargées. (2 750 mots & fig.)

1959 **656** .223 .2 = 491 .7
Jelesnodorosnuy Transporte, février, p. 67.
SOUBBOTINE (A.S.). — **Amélioration de l'utilisation de la capacité de chargement des wagons** de marchandises comme réserve de l'augmentation du rendement du travail. (2 500 mots.)

1959 **625** .22 = 491 .7
Jelesnodorosnuy Transporte, février, p. 87.
OSTROV (A.B.). — L'**unification des gabarits** des chemins de fer des pays socialistes. (3 600 mots & fig.)

1959 **656** .2 = 491 .7
Jelesnodorosnuy Transporte, mars, p. 15.
LIGNEKOV (M.V.). — Sources d'un **nouveau développement du rendement du travail** dans le transport ferroviaire. (2 100 mots.)

1959 **621** .431 .72 = 491 .7
Jelesnodorosnuy Transporte, mars, p. 31.
KONOVALOV (S.E.). — Réduction des dépenses dans l'**organisation de la traction Diesel.** (2 000 mots & fig.)

1959 **656** .25 = 491 .7
Jelesnodorosnuy Transporte, mars, p. 34.
CHOUKHATOVITCH (L.I.) & LASKINE (E.D.). — Augmentation de la **sécurité d'exploitation des chemins de fer électrifiés.** (2 200 mots & fig.)

In Russian (+ German and Chinese) (= 491.7).

Bulletin de l'Organisation de Collaboration des Chemins de fer (OSShD). (Varsovie.)

1959 **385** (06 = 491 .7
Bulletin de l'OSShD, n° 1, p. 1.
DRAZKIEWICZ (H.). — L'**Organisation pour la Coopération des Chemins de fer** et son Comité de Transport ferroviaire. (2 800 mots.)

1959 **385** .114 (437) = 491 .7
Bulletin de l'OSShD, n° 1, p. 5.
GOELER (O.). — Méthodes de **calcul des prix de revient** du transport ferroviaire en Tchécoslovaquie. (4 900 mots.)

1959 **625** .28 = 491 .7
Bulletin de l'OSShD, n° 1, p. 12.
KALININE (S.S.). — Application de la **traction par autorail et électrique en transport voyageurs.** (4 000 mots & fig.)

1959 **385** (06 = 491 .7
Bulletin de l'OSShD, n° 2, p. 5.
POPESCU (P.). — La **collaboration technico-scientifique** entre les membres de l'OSShD. (3 000 mots.)

1959 **385** .517 .6 = 491 .7
Bulletin de l'OSShD, n° 2, p. 9.
KRETSCHMER (Dr. R.). — Le **médecin au service des chemins de fer.** (3 250 mots.)

1959 **625** .216 = 491 .7
Bulletin de l'OSShD, n° 3, p. 3.
STANKIEWICZ (L.) & TIMOCHENKOV (I.T.). — Sur la nécessité de l'introduction de l'**attelage automatique aux chemins de fer.** (2 800 mots & fig.)

In Serbo-Croat (= 91.882).

Elektrotehniški Vestnik. (Ljubljani.)

1959 **621** .3 (= 91 .882)
Elektrotehniški Vestnik, n° 3-4, p. 85.
TAVZES (R.). — Comparaison des propriétés et de l'applicabilité des **redresseurs à semi-conducteurs.** (1 500 mots & fig.)

In Czech (= 91.886).

Inženýrské Stavby. (Praha.)

1959 **625** .142 .4 (437) = 91 .886
Inženýrské Stavby, 5 décembre, p. 437.
BÚTOR (J.). — Extension de l'emploi de **traverses de chemins de fer en béton précontraint** en Slovaquie. (3 000 mots & fig.)

1959 **691** = 91 .886
Inženýrské Stavby, 5 décembre, p. 448.
KOČI (B.). — **L'influence des températures élevées sur le béton.** (3 000 mots & fig.)

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